The proposed ideas hypothesize possible acquisitions and vertical backwards integrations, that is, large original equipment manufacturer that wish to integrate smaller companies capable of reducing their operating costs.

The final aim will be to demonstrate how, based on the expected growth of the electric car market, it is possible to make profitable investments both from a value investing perspective and by making business choices oriented to a more efficient production processes.

Chapter 1: Renewable energy market outlook

Introduction

The aim of this first chapter is to give an outlook on the renewable energy market with specific attention to the automotive segment. Basing on the government's declarations and automotive companies' announcements it is fairly simple to understand that in the next decade traditional energy sources will be gradually reduced to counteract the incumbent climate change, which is increasingly manifesting itself with extreme atmospheric events.

The analysis will involve the observation of historical data to predict the magnitude of the renewable energy market, considering both primary energy sources and automotive products too. Vehicles' innovation seems to be of fundamental importance for the environmental protection since the traditional system of transport is responsible for 30% of the total CO2 emission[1], the most relevant part of which comes from road vehicles. However, the analysis will not be focused on chemical and environmental data but rather on economic indicators mostly related to the automotive industry. Attention will be also paid to non-financial data which bring important information to understand the efforts that the companies taken into consideration are making in order to develop electric vehicles. Among the indicators that are taken into consideration there will be the expenditure for research and development, the quantity of cars sold and the statements announced by business management regarding the policies adopted for the next decade: pieces of information that denote companies' orientation basing on what has been done so far and what it is intended to do.

Scientific innovation plays a fundamental role for the implementation of electric mobility; in addition, as it can be deduced from the data that will be reported, the announcements of technological achievements are of great value for companies, since their share price has always reacted with substantial increases, in some cases even excessive[2].

To allow an adequate development of the renewable energy and electric vehicle markets it is important to meet the need for substantial infrastructures implementation (for example quicker charging stations), and also the improvement in efficiency associated with a reduction in costs; all these characteristics result to be essential in order to guarantee an improvement in costumers sentiment and therefore, as a direct consequence, to increase the volume of sales.

This first superficial study is fundamental to start the overall analysis which has as its purpose the observation of companies closely connected with the automotive market but not yet strongly established,

[1] Data referred to European Union. European Parliament official site, *CO2 emissions from cars: facts and figures*
[2] For example, Tesla, Inc. in the last two years: May 2019 - May 2021

which may represent business partners capable to support and cooperate with manufacturers (especially with regards to energy technologies[3]) to achieve the expected results in the next future.

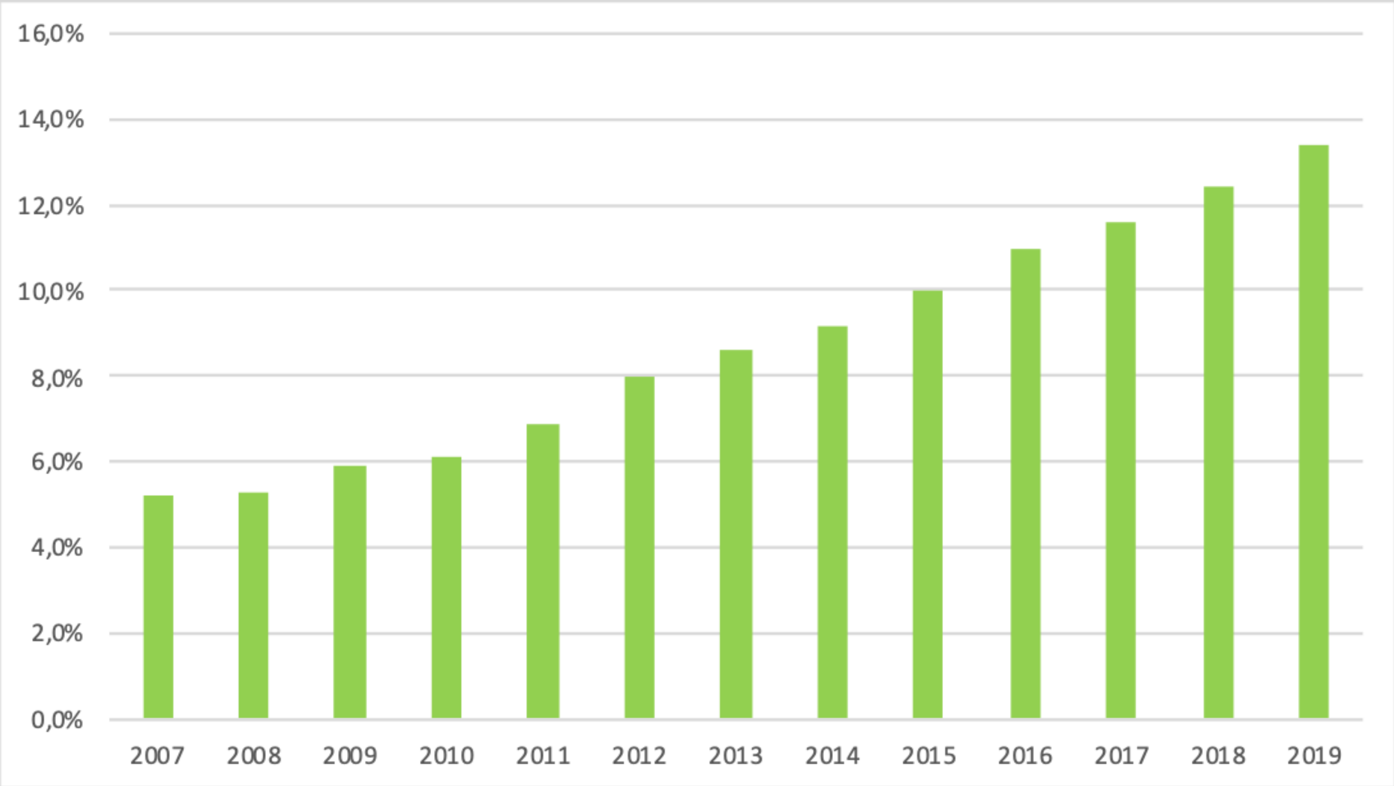
[3] As Maxwell Technologies Inc. for Tesla

1.1. Renewable energy[4]

The current environmental problem related to different types of pollution derived by the most used sources of non-renewable energy as crude oil, coal and nuclear reactor, has strongly raised awareness in governments and consequently in the economic world. The share of energy produced by renewable sources during the last years has grown from 5,2% in 2007 to 13,4% in 2019.

Table 1.1.1)

Shares of renewable in global power production (2007-2019)[5]



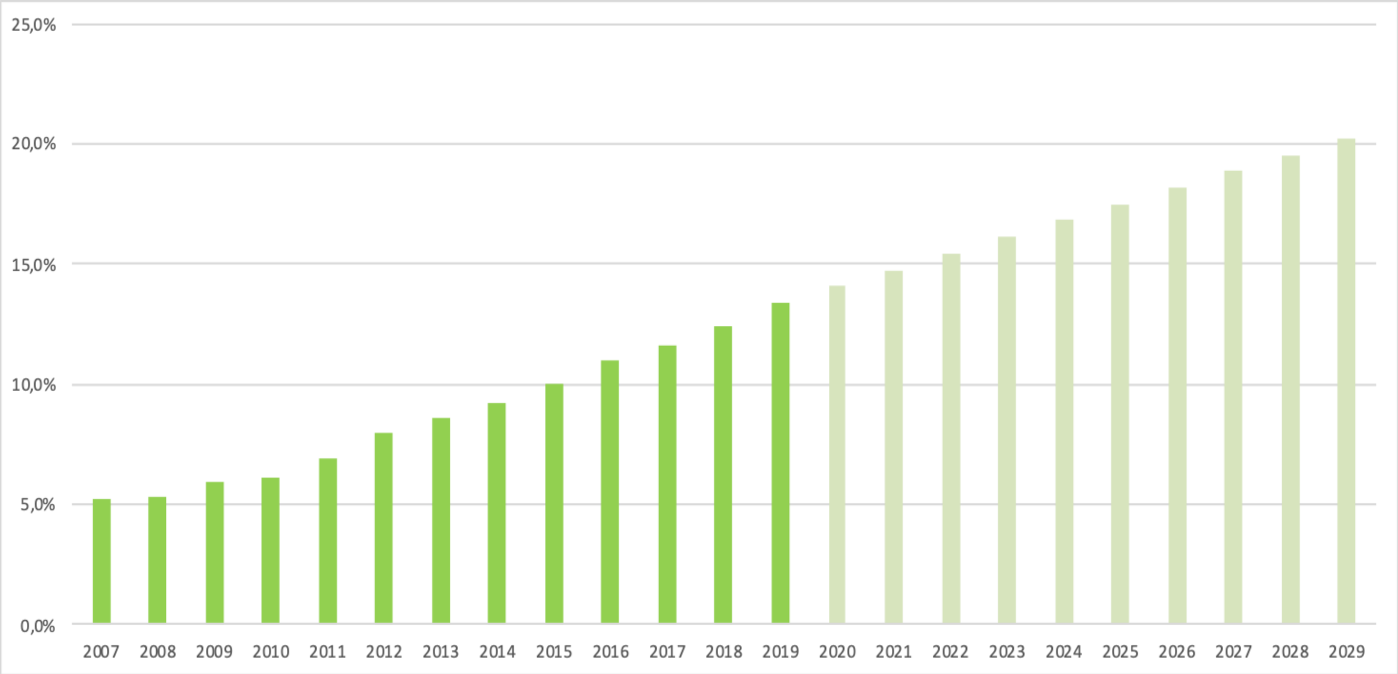
Source: Statista (Bloomberg New Energy Finance; UNEP; FS-UNEP Collaborating Centre)

As we can observe from the diagram, the growth rate of r.e. shares fluctuate between 0,10% and 1,10% with an average increase of 0,68% per year. The following diagram shows a simplified forecast which probably is affected by underestimation caused firstly by the exclusion of hydropower energy sources[6] and secondly by the unpredictable effects of the “Green policy” that could change the expansion from a linear to an exponential model of growth.

[4] From now on I will be referring to renewable energy with the abbreviation r.e.
[5] Large hydropower sources excluded
[6] Information not included in dataset

Table 1.1.2)

Forecast for shares of renewable energy in global power production (2007-2029)[7]



Source: Statista (Bloomberg New Energy Finance; UNEP; FS-UNEP Collaborating Centre)

This assumption implies that before 2030 more than a fifth of the global energy produced will come from renewable sources and, in addition, provides information about the economics magnitude of profits that can be achieved with selected investments. As ten years ago e-commerce companies had an important growth capacity, due to internet development and a constantly increasing demand, r.e. businesses hide an important margin of growth if adequately managed.

According with Bloomberg's New Energy Outlook 2020[8] the necessary investments for a relevant sustainable energy development amount to 3,547 USD trillion[9] in the next 10 years.

Despite the fact that perplexities about r.e. still exist, the gap between r.e. and traditional energy sources with regards to critical factors like supply continuity, distance from built-up area and the still high prices - that maintain margins of profit low - is slowly decreasing, carrying the r.e. to a more reliable and economical operating business model.[10]

It is a matter of fact that r.e. market is growing rapidly involving all the segment related to it, like corporates that produce solar cells, wind turbine, electric vehicle and essential parts like li-ion battery.

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[7] Forecast and diagram computed with Microsoft Excel

[8] Will Mathis, Jeremy Hodges, *Green Power to Draw $11 Trillion Investment by 2050: BNEF*, <Bloomberg> 2020

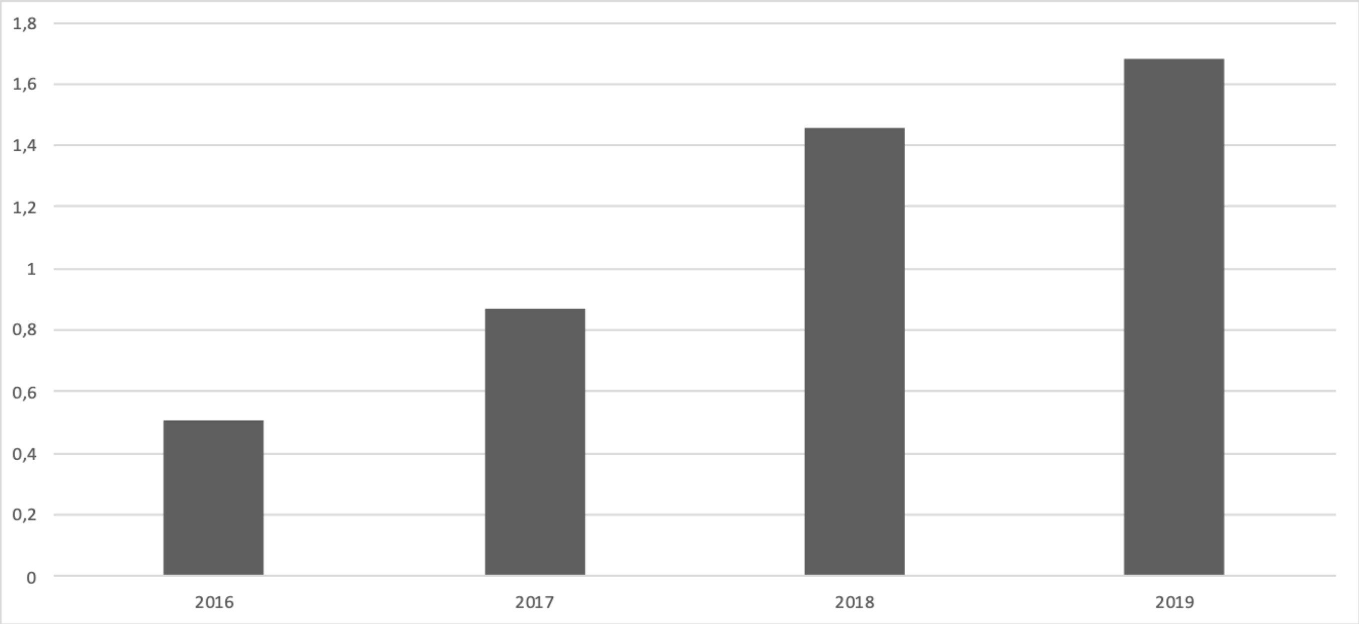
[9] The Bloomberg's New Energy Outlook 2020 reports that in the next 30 years the global planned investment is around 15.1 trillion dollars, or about 486 million per year, of which 73% dedicated to renewables, therefore in the next 10 years: $486b * 0{,}73 * 10y$ = 3.547 USD trillion globally

[10] Brad Carson, *The Economics of Renewable Energy*, <SSRN>, pag. 1-2

These markets are obviously closely linked since the government intervention about sustainability applies to the various segment that deal with green energy and in addition, the use of electric vehicles using electrical power obtained from non-renewable sources would be absurd in terms of environmental sensitivity. To confirm what just reported, the following diagrams shows the sales for electric vehicle battery and plug-in electric vehicle worldwide in 2016-2019.

Table 1.1.3)

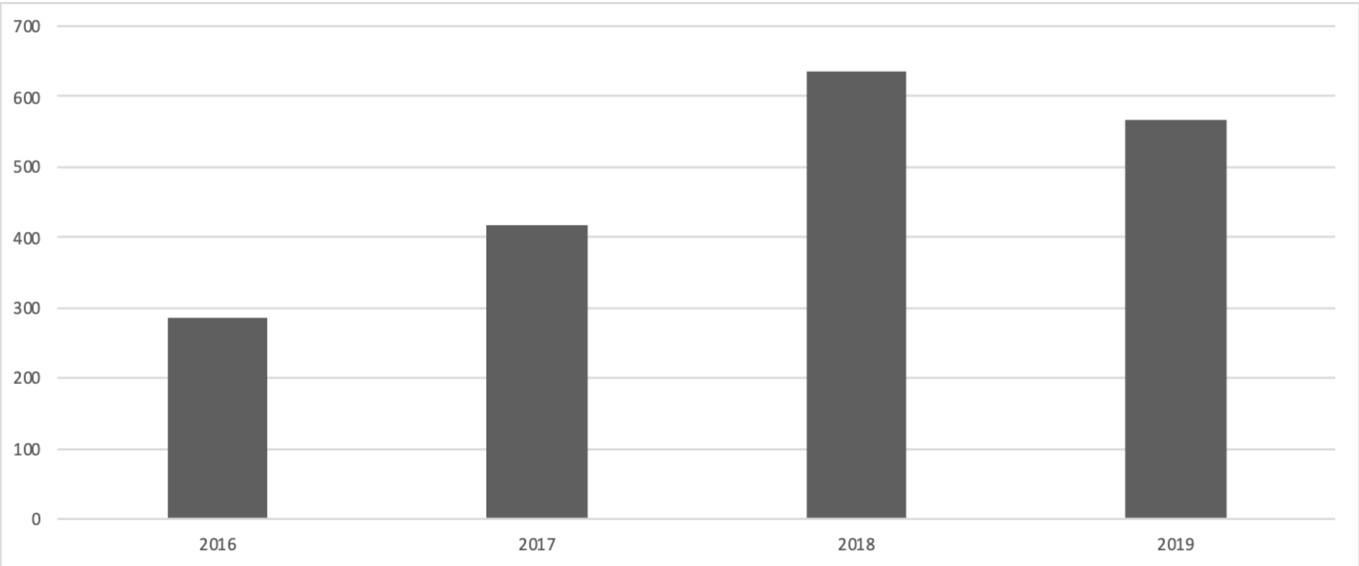
Global sales of battery-electric vehicles (Unit sales in millions)



Source(s): Statista, Frost & Sullivan; ID 1059214

Table 1.1.4)

Plug-in electric vehicle sales worldwide (in 1,000 units)



Source(s): Statista, IEA; ID 442759

As can be seen from the data reported, even though the sales of electric vehicle worldwide decreased in 2019 and in the first quarter of 2020, the underlying trend shows growth: any trend's reversal depends on specific regional demands and unpredictable events like the COVID-19 financial crisis. In contrast to the globally slowdown of 2019 Europe expanded its market share to 26 percent.[11]

For further confirmation of what has been reported so far, the correlation index[12] between the development in r.e. market and sales in electric vehicle during the period 2012-2019 can be calculated as follows:

```
. spearman EVSales reGlobalProduction

 Number of obs =       8
Spearman's rho =       0.9762

Test of Ho: EVSales and reGlobalProduction are independent
    Prob > |t| =       0.0000
```

the correlation is equal to 97.62% with p-value close to zero.

[11] Thomas Gersdorf, Patrick Schaufuss, Stephanie Schenk, Patrick Hertzke, *McKinsey Electric Vehicle Index: Europe cushions a global plunge in EV sales*, <McKinsey&Company>, 17 July 2020

[12] Computed with STATA/MP 14.1

1.2 The Electric Vehicles segment

As showed in the previous paragraph, it is a matter of fact that electric vehicle market is growing rapidly and offers great opportunities of profitability to the operating companies. In the next future the main opportunities for profitability will depend heavily on technological innovation that will allow enterprises to keep production costs relatively low producing high-performance car in terms of driving range and time required to charge. Assuming these considerations, EV market growth could be exponential in case electric car prices will align to classic ICE[13] car. Forecasted data shows that the sale of EV units will grow from 3,269,671 of 2019 to around 26 million in 2030 with a CAGR of 21,1%[14]. The following analysis shows the market volume in USD in 2019 and 2030.The cars taken into consideration are built by the five main manufacturers and represent the economic offer, so intentionally luxury cars[15] were excluded. The forecast implies an average increase in price of 3000$ for standard optional and a 30% reduction in car prices over the eleven years considered. This hypothesis is based on the opportunities of making the mining and production operations of raw materials, such as lithium and cobalt, less expensive in the coming years.
The establishment of commercial relationships with companies operating in this fields can represent a key aspect for a rapid development of EV that would be decidedly cheaper, however with good margin of profit for producers. In the last two chapters, the research will focus precisely on this goal.

Table 1.2.1)

Car Considered	**Price (without optional)**		
VW iD3	34,800	€	
Tesla Model3	36,990	$	
BYD SongMax	160,000	¥	
BMW i3	40,600	€	
Nissan LEAF	29,300	€	
Average+Optional =	$ 40.041,98		
	EV Units Sold	**Avg. EV Price**	**Market Volume in USD**
2019	3,269,671	$ 40.041,98	$ 130.924.100.788,58
2030	26,951,318	$ 28.029,39	$ 755.428.895.430,75

[13] Internal Combustion Engine
[14] *Electric vehicle market*, <MarketsandMarkets>, June 2019 | Report Code: AT 4907
[15] Premium cars with price over 50.000$

Considering these numbers with a medium net profit margin of 7%[16] and the exclusion of luxury cars the global net profit volume calculated will be of over 52 billion Dollars in 2030 solely from sales[17].
As previously reported, technological innovation plays a fundamental role for the EV market expansion. Corporates will have to face various challenges to incentivize customers to buy an electric car.
The biggest challenge will consist into the improvement of technological factors that drive the growth in order to produce an optimized vehicle in term of price/benefits.
Customer's sentiment will be another key factor to work on in the coming years and will involves a great deal of marketing research. Recent surveys[18] show that customers' aversion to buy an electric vehicle primarily depends on some relevant factors including driving range, time required to charge, safety concern with battery technology and lack of EV charging infrastructure, this last one strongly presents in United States and Italy respectively 29% and 32% in 2020. With these data it is possible to rank the above-mentioned critical aspects; firstly, there is a widespread lack of charging spots; secondly, there are concerns about the driving range and subsequently, slightly depending on the geographic area, the time required to charge and the cost/price premium.
On the other hand, corporates will be supported by important incentives made by government interventions which in part have already been implemented and which will turn out to be fundamental for the cultural and environmental shift.
In Italy the first legislative intervention granted the removal of parking tax and city access restrictions: measures that, however, did not affect the general sentiment about EV because of the still numerous cons previously reported. A stronger push from the governments for the sustainability shift involves more penalizing measures for old ICE highly polluting vehicles and attractive financial incentives for the purchase process of an electric car. A recent study[19] report that in the US a 25% replacement of ICEs with EV would bring several social and economic benefits. The study found that by replacing 25% of internal combustion engine vehicles with electric cars, assuming no interventions on the current energy supply system, over 500 premature deaths would be prevented and around 16.8 billion of USD saved in "damages avoided[20]"; if the replacement would involve 75% of the cars, the benefits would increase significantly to reach $70 billion saved.

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[16] I. Wagner, *Profit margin of major car companies June 2020*, <Statista>, 16 November 2020.
[17] The automotive business segment traditionally produces substantial revenues not only from sale price but mostly with aftersale services, among which there are periodic maintenance, reparations and the financial service offered to customers, such as credit, leasing and insurance. See Deloitte, Future of Automotive Sales and Afetrsales impact of current industry trend on OEM revenues and profits until 2035, 2020, pag. 14.
[18] Deloitte, *Electric vehicles. Setting a course for 2030.*
[19] Peters et al., *Public Health and Climate Benefits and Trade-Offs of U.S. Vehicle Electrification*, p.1 <GeoHealth> 2020.
[20] The damages refer to extreme climatic events that tend to occur due to the rise in temperatures mainly caused by greenhouse gases.

As previously said, companies' management plays a fundamental role: car producers should focus on selected investments in technological innovation in order to maximize cars performance and, in addition, they should build strong and profitable relationships with suppliers.

The concrete achievement of these objectives should bring the market to an average price reduction for economy cars, boosted both by the growing offering and by a greater competitive efficiency: it is desirable, in fact, the improvement of the price/benefits ratio in order to gain customers which are price sensitive. The increased availability of EV models in the next decade is supposed to provoke the alignment of the average prices of electric cars to the ICE: if these conditions are achieved, the forecasted sales results will coincide with the data previously reported.

Ultimately, the factors that mostly affect profitability results to be batteries and electrical motor, that are the components with the highest added value if adequately developed with commensurate R&D investments.

In order to assess the risks of the EV production it is possible to deduce that the power of suppliers, which produce high developed and tested components like engines or batteries, will be the most influential for market and companies. Targeted collaborations between strategic suppliers and original equipment manufacturers (OEM)[21], or M&A activities, could strongly cut operating costs thanks, for example, to the possibility of vertical integration. A second major risk is the rivalry among competitors which should be properly evaluated in order to maintain competitiveness and profitability but at the same it should be able to nudge new customers to purchases. Threats of substitute should be considered less alarming, since the cultural shift in favor of electric mobility is strongly encouraged with important financial incentives that seem to grow over time. At the same time, threats of new entrants could play a secondary role, being the automotive market already extremely competitive. The likelihood that a new company, given the high entry barriers, could quickly create a business model capable to steal a relevant market's slice to more consolidated and older competitors is extremely low.

[21] Company that produces original components and, after assembled, sells them both as finished products or as individual components.

1.3 Leading Companies in the sector

The EV segment represents one of the most promising market for the next future. Companies that already operate in this field are in a situation of great advantage for profitability, considering the rapid development this market is facing. The most important advantages they have are represented by the advanced technological knowledge already achieved and the existing customer relations, that are valuable, intangible assets brought by the loyalty to the brand that the users develop after acquiring a product and having a good experience using it.

The following table[22] shows some financial and non-financial data that shows an overview on five of the top companies' presence in the market.

Table 1.3.1)

In million	USA	USA	Europe	Europe	Japan
	Tesla	General Motors	BMW	Volkswagen	Toyota
Research and development expenditure	$ 1.491	$ 6.200	$ 7.330	$ 16.576	$ 10.209
Share price in USD	$ 661,18	$ 55,94	$ 99,60	$ 270,28	$ 151,32
Market Capitalization	$ 635.366	$ 80.633	$ 64.392	$ 164.759	$ 210.265
Price-to-Research Ratio	426.13	13.01	8.78	9.94	20.60
EBIT	$ 1.902	$ 9.193	$ 6.536	$ 10.097	$ 18.958
EBITDA	$ 4.224	$ 22.008	$ 13.915	$ 40.645	$ 33.970
Gross Profit	$ 6.630	$ 13.672	$ 13.774	$ -1.581	$ 42.076
Operating expenses	$ 4.636	$ 7.038	$ 7.659	$ 38.105	$ 24.500
Operating income	$ 1.994	$ 6.634	$ 6.115	$ -39.685	$ 17.576
Net income	$ 690	$ 6.321	$ 4.165	$ 5.474	$ 16.877
Number vehicles sold in 2020	499,000	6,830,000	2,325,180	5,328,000	8,692,168
Exchange rate EUR/USD	1,1938[23]				
Exchange rate JPY/USD	0,009195[24]				
EV sold	499,000	-	-	-	3,346
HEV sold	-	-	-	-	1,954,454
Total electrified sold	499,000	-	192,662	212,000	1,957,800
Percentage on total Cars sold 2020	100%	-	8.29%	3.98%	22.52%

[22] The financial information sources are: corporates official 10-K for the fiscal year ended 31 December 2020, Yahoo finance, corporates 2020 annual report and companies' official site.
[23] Il Sole 24 Ore, 22 March 2021
[24] Wall street Journal, 22 March 2021

1.4 Conclusion

The study done so far has shown an important growth in energy produced by renewable sources and, in equal measure, the development of EV. The data observed show a constant and linear growth in the past ten years, however there are reasons to think that in the next future the expansion of these markets can assume an exponential trend, primarily because of the economic restart after the covid-19 pandemic and secondly thanks to government policies oriented to encourage the purchase of EV and the gradual disposal of classic ICE cars. At the moment there are several concerns that customers have about EV: main ones are the absence of an infrastructure system that guarantees the usability of these new type of cars, the driving range and the price which at the moment remains accessible only to people with an above average salary. Automotive companies from every region are showing great commitment to speed up the replacement of classic gasoline and diesel vehicles. Undoubtedly one of the factors that will contribute the most to the implementation of the new way of mobility is the scientific innovation with specific regard to the characteristics that makes a car efficient, safe and simple to use. Realistically lithium-ion battery are the components with the highest value and with the highest margin of improvements.

Companies' management must properly evaluate the choices to be made in the coming years in order to lower prices, increase efficiency and maintain profitability. Strategic suppliers are a high value resources for companies which should invest in solid relations with them in order to benefit from collaboration, especially regarding the raw materials market; one example is the acquisition of Maxwell technologies by Tesla in 2019. As a consequence of this operation, Tesla's share price has gradually increased over the last two years, though with considerable fluctuations. This effect is an index of how investors trust the fact that technological innovation and research oriented to the systems efficiency will lead to relevant future financial results, however the rise that Tesla has undergone in the last two years is also due to an excessively optimistic market sentiment that has brought the stock value to a level that cannot be justified by the current company development[40].

Market trends and companies' performance indicate that expectations regarding the development of the electric car market are high and that they can only be justified with a significant increase in the fleet of electric vehicles. At the moment this purpose results to be achievable through company processes oriented to reduce the average price for an EV, with the support of policies aimed at encouraging its use. Despite the widely affirmed skepticism on EV market, which support the idea that electric mobility is just a speculative bubble with inevitable imminent stocks collapses[41], it is a matter of fact that only through government reforms events like the one happened to Tesla, which had an excessive raise in stocks market for the current business development, could be justified.

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[40] At 22 May 2021 Tesla has a Price/Earnings ratio equal to 582,04.
[41] Jamie Powell, *The EV bubble spreadsheet: update dos*, <Financial Times>, 1 February 2021

Chapter 2: Green policies

Introduction

The second chapter analyze several concepts necessary to understand how much the electric vehicle market is sensitive to economic policies and how convenient it is, both from an economic and environmental point of view.

The first part will examine the different kind of incentives that can be given to increase the development of the electric car sector.

The analyses are based on historical data observed in thirty different countries.

The models used are mostly linear regressions and the aim is to identify any relationship between governments interventions and the EV’s market share.

What is expected to observe is a fairly strong relation between economic policies and market development; in fact, to reduce significantly the purchase price, which at the moment is one of the main reasons that obstacles a capillary circulation of EVs, effective policies are absolutely necessary.

Another aspect observed concerns the "interaction" effect that occurs in the case in which economic incentives are combined with a good infrastructures implementation for electric cars, which seems to amplify the effects of investments. Moreover, the analysis shows that a stalemate can occur in some country, that is, the impossibility of creating a base of efficient and profitable infrastructures for the development of the EV's market without the electric car market being already sufficiently evolved.

The second part examines the relations between renewable energies, electric vehicles and crude oil market. Part of the results relating to renewable energy are associated to the electric vehicle market share because of the lack data related to the EVs and since the two markets are closely correlated as previously verified in chapter one.

What is expected to observe is a positive relationship between the crude oil price and the development of renewable energies, i.e., if the price of oil increases there will be a greater necessity to find a substitute goods which in this case is represented by the RE.

Another hypothesis proposed concerns the possibility that oil companies, in the case in which they perceive a threat to their business, in order to continue selling crude oil, could lower the price, preventing a rapid development of renewable energies and therefore of electric cars.

The last part will address the issue of the environmental impact caused by the electric cars at all stages of the vehicles' life, trying to understand the quantity of emissions produced by the two main types of cars, namely ICE and EV, in order to identify the economic and environmental benefits associated with the electric mobility.

The objective of this chapter is to support the thesis that electric cars represent a good alternative to improve the environmental impact and the economy of private transport, offering high business investment opportunities.

2.1. Policies as a discriminant for investments and sales

At the moment the traditional ICE cars remain the most economic[42] automotive products for companies and also for buyers, which have to bear a cost sharply lower compared to the average EV's price. The transition to the massive use of innovative and sustainable private vehicles should be strongly incentivized with policies capable of guiding the investment choices of both companies and consumers. Transport sector is one of the main contributors to the greenhouse gas emission with the 23% of the total[43], so result to be imperative the implementation of effective government programs. It is possible to use several different policies, mainly subsidies and tax with specific exemptions in order to offer customers savings possibilities. An approach that has already been shown to be effective concerns the incentives that can be exploited by companies to increase their R&D expenditure[44]. The potential of technological development is still high and with time will gradually decreases but now, all the available and usable resources should be used to increase efficiency and, above all, to reduce prices.
The following table shows the main types of policies that can be adopted.

Table 2.1.1)

Policy Measure	Description
Monetary	
(1)	Direct subsidies for an EV purchase
(2)	Road Tax Exemption
Traffic regulations	
(3)	Free Use of Bus/Fast Lanes
(4)	Free City Center Parking
Charging infrastructure	
(5)	Charging at Public Parking
(6)	Charging at Workplace
(7)	Charging Network on Freeways

Source: Theo Lieven, *Policy measures to promote electric mobility – A global perspective* in Transportation research part 1, p. 80 <ELSEVIER>, 2015.

There are basically three macro-areas on which it is possible to intervene: Monetary policies or financial incentives, traffic regulations and infrastructure. In the group (1) of the previous table should be included

[42] In the most theoretical sense of the term: the most efficient and effective use of the available resources.
[43] Petra Zsuzsa Lévay, Yannis Drossinos, Christian Thiel, *The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership* in Energy policy p. 524, <ELSEVIER> 2017
[44] Theo Lieven, *Policy measures to promote electric mobility – A global perspective* in Transportation research part A, p. 79 <ELSEVIER>, 2015

subsidies exploitable not only by buyers but also by corporates, like the incentives on R&D expenditure previously mentioned. The first analysis proposed concerns the study of how diverse economic variables, including aggregate[45] incentives, influence the EV market share in different nations. The appliance used is a liner regression model[46]. The data cover thirty countries and include as independent variables: financial incentives, urban density, education level, fuel price, EV price, per capita vehicles, model availability, presence of production facilities, an environmentalism indicator, introduction date, charging infrastructure and electricity price.

Table 2.1.2) shows the results.

Table 2.1.2)

	Unstandardized B (Std. err.)	**Standardized Beta**
(Constant)	−5.703 (2.858)	
Incentive	0.006 (0.003)*	0.357
Charging infrastructure	0.131 (0.039)**	0.599
Environment	0.020 (0.037)	0.106
Fuel	−0.141 (0.827)	−0.031
HQ	0.926 (0.492)$^{+}$	0.312
Income	−0.046 (0.036)	−0.336
Per capita vehicles	0.003 (0.002)	0.319
Education	0.030 (0.003)	0.190
Electricity	−0.221 (0.282)	−0.115
Availability	0.049 (0.056)	0.178
EV introduction	0.122 (0.232)	0.106
EV price	0.008 (0.029)	0.046
Urban density	0.018 (0.077)	0.056
N	30	
R^2	0.792	
Adjusted R^2	0.623	

* $P < 0.05$.
** $P < 0.01$.
$^{+}$ $P < 0.1$.

Source: Theo Lieven, *Policy measures to promote electric mobility – A global perspective* in Transportation research part A, p. 80 <ELSEVIER>, 2015.

[45] The regression model proposed includes a variable for incentives which however are not distinguished in different categories as in the table 1).

[46] William Sierzchula, Sjoerd Bakker, Kees Maat, Bert van Wee, *The influence of financial incentives and other socio-economic factors on electric vehicle adoption* in Energy policy, p. 190 <ELSEVIER> 2014

The only two coefficients statistically significant at 95% and 99% are only the "incentives" and the "charging infrastructures[47]" respectively, marked with an asterisk which associates the coefficients to an interval of p-value; this means that increasing one of these two factors, the EV market share tends to increase. The adjusted R-squared is high enough to affirm that the model is robust and the acceptable variables[48] explain a fair part of EVs market share variation. The coefficients show that the presence of charging infrastructures affects the numbers of EVs more than how financial incentives do.
However, there are some considerations to discuss about this assertion.
With the present charging technology, the medium time required to accumulate energy for 62 miles is estimated around 3 hours[49] and considering that in 2017 the daily average distance driven was 26 miles[50], in order to make an electric car economical in logistical[51] terms, a widespread presence of charging columns is required[52].
Whereas available batteries in 2021 guarantee an autonomy that starts from 200 miles up to 400, farther, innovative charging systems have reached results that guarantee complete energy refill in just few minutes[53].
If we consider the possibility that there is margin of improvement in the charging systems velocity, appears unnecessary to invest heavily in the implementation of a capillary recharging infrastructure system, in fact, with these assumptions is not difficult to imagine petrol stations that work like traditional petrol pumps with the difference that the refueling would be electric. A further analysis carried out considering 30 different states (USA, China, Italy, France, Spain, UK, Canada, Portugal, Norway, Switzerland, Hungary, India, Japan, Poland, Belgium, Germany, Finland, Bulgaria, Greece, Brazil, Mexico, South Africa, Australia, Singapore, Egypt, U.A. Emirates, Saudi Arabia, Morocco, Albania, Russia) and using data relating to 2019 shows that the presence of charging infrastructures is strongly correlated to the countries' GDP.

```
. spearman GPD ChargInfrastructure

 Number of obs =      30
Spearman's rho =       0.6135

Test of Ho: GPD and ChargInfrastructure are independent
    Prob > |t| =       0.0003
```

[47] It is a measure that indicates the concentration of recharging systems available for use in a specific country.
[48] "Acceptable" refers to the beta outputs with a p-value lower than 0.05 and 0.01, ensuring a statistical significance level of 95% and 99% respectively.
[49] Statista Research Department, *Europe: charging times to provide 100km of battery electric vehicle driving in 2013*, <STATISTA>, 2016
[50] I. Wagner, *Daily travel miles per driver - United States 2001 to 2017*, <STATISTA>, 2021
[51] Excessively prolonged charging times, if not justified by a generous autonomy, makes electric cars very inefficient if compared to an ICE for which refueling takes only a few minutes.
[52] The extremely widespread presence of recharging systems, including private ones, would certainly have an important impact on the adoption of electric cars, however it could become obsolete and useless within a few years.
[53] For example: chargers with a capacity greater than 150kH.

```
. spearman AvSalary EVMarketShare

 Number of obs =      24
Spearman's rho =       0.7045

Test of Ho: AvSalary and EVMarketShare are independent
    Prob > |t| =       0.0001
```

Moreover, the data for 2019 shows that the electric vehicle market share is strongly correlated to the countries' average salary, this result clearly shows that the main obstacles to buy an EV is the non-competitive price[54], so policies focused on substantial monetary deduction during the purchase would affect the EVs market share considerably. P.Z. Lévay[55] et al. conducted a study oriented to the calculation of the Total Cost of Ownership (TCO) which incorporates all current and future costs that a buyer bears during the ownership period.

The TCO is calculated as: $TCO = P + VAT + T_r - S + T_c + F - R$, where P is the net price, VAT is the value added tax, T(r) is the sum of all the other tax acquisition, S is the exploitable subsidies during the purchase, T(c) is the present value of annual circulation taxes, F is the present value of fuel or electricity costs and R is the resale value of the vehicle.

The authors specifies that maintenance costs are not incorporated in the model as they depend heavily on the owner's use and for this reason they are extremely variable.

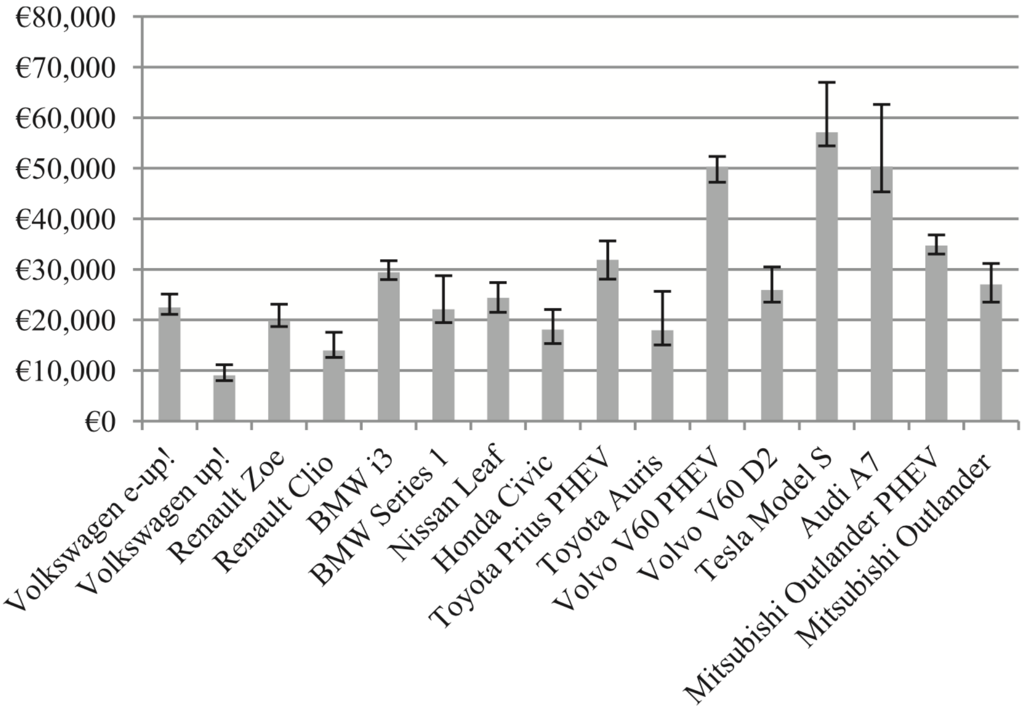
The results are reported in table 3. Similar cars models are placed side by side in the graph with the only difference in the type of engine.

Main results show that all the EVs considered are more expensive than the comparable ICE cars, in addition, smaller EVs seem to be more expensive than larger electric cars, contrary to the ICE vehicles for which has always been the opposite due to savings on fuel and small components.

[54] A high salary allows the buyer to have a greater freedom of choice in the acquiring process.
The percentage of salary allocated to the purchase of a private vehicle can be higher and the customer can attribute more value to the long-term fuel savings as well as fees deduction on EV, investing an higher sum immediately, besides gaining the prestige of owning a "green" vehicle.

[55] Petra Zsuzsa Lévay, Yannis Drossinos, Christian Thiel, *The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership* in Energy policy p. 528, <ELSEVIER> 2017

Table 2.1.3)



A specific example: The VW e-up!'s buying price is 30,100 euros in UK, with the available subsidies the cost decrease to around 23,900 showing a reduction of more than 20%[56]; although, in some states, the presence of subsidies allows for substantial deductions on the purchase cost and, even if there is a fair margin of savings on fuel, EVs are still not competitive compared with ICE cars.

Regard to monetary policies that involve the presence of subsidies, it is important to evaluate the free-riding problem. Theo Lieven (2015)[57] affirms that approximately 45% of incentives went to buyers who didn't really need it or who would have bought a new car anyway.

In order to avoid unnecessary expenses the financial incentives must be carefully evaluated by policy makers.

At the moment policies themselves do not seem effective enough to make an electric car convenient in the short term[58] compared with the ICE pair, with the sole exception of Norway where EV, thanks to the strong incentives, are price competitive.

Even if the model incorporates the cost of fuel and electricity, these factors do not seem to affect substantially the TCO which remains high for EVs; the cost of fossil fuel is not excessively high and the cost of electricity is not low enough to guarantee drastic differences in spending levels.

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[56] Petra Zsuzsa Lévay, Yannis Drossinos, Christian Thiel, *The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership* in Energy policy p. 529, <ELSEVIER> 2017

[57] Theo Lieven, *Policy measures to promote electric mobility – A global perspective* in Transportation research part A, p. 79 <ELSEVIER>, 2015

[58] A period of time between 1 and 5 years, an analysis that studies a longer period of ownership would be excessively dependent on incalculable factors linked to the owner's characteristics.

It is also reasonable to think that in states where the price of fuel is below the average and EVs market share is developed, the factors that contribute to incentivize the choice of electric cars are mainly social and cultural.

However, from the previous analysis, it is evident that the results for the EVs market share is affected strongly by the total purchase price which can be heavily reduced impacting incentives and costs reduction. The component that keeps the gap price so wide between EVs and ICE cars is the battery that, despite have increased significantly in term of efficiency and cost convenience, remains the discriminant for a substantial reduction. If the production costs of batteries for electric engines will reduce appreciably in the next few years, the widespread use of EVs will become increasingly real evidence.

2.2 Effectiveness of policies

To confirm what reported so far Rietmann and Lieven[59] propose a structural equation model (SEM) which incorporates part of data previously analyzed but related to 2017, plus additional information like national purchase price (PP) and stations per highway km, in order to understand which policies are most effective to succeed in the implementation of fully electric mobility. The model includes a numerical variable for the traffic regulation[60] and a monetary evaluation of the incentives that consumers can benefit in each of the 20 states considered.

Results are reported in table 2.2.1 and 2.2.2

Table 2.2.1)

Data for 20 countries.

Country	PHEVs and EVs sold in 2017	Total sales 2017	EV Market Share 2017	Monetary Measures
AU Australia	2,176	915,219	0.24%	**1000**
BE Belgium	14,885	546,533	2.72%	**10,000**
BR Brazil	66	1,844,394	0.00%	**500**
CA Canada	18,596	639,272	2.91%	**10,000**
CH Switzerland	8,139	314,145	2.59%	**5,000**
CN China	601,752	24,961,948	2.41%	**6,000**
DE Germany	58,299	3,442,100	1.69%	**8,000**
FR France	42,691	2,109,890	2.02%	**8,000**
HK Hong Kong	4,163	39,245	10.61%	**12,400**
IN India	2,312	3,227,701	0.07%	**2,355**
IT Italy	5,101	1,969,140	0.26%	**5,000**
JP Japan	56,507	4,391,100	1.29%	**5,000**
KR Korea	13,943	1,495,468	0.93%	**5,000**
NL Netherlands	9,745	414,599	2.35%	**12,500**
NO Norway	63,228	158,623	39.86%	**25,000**
RU Russia	96	1,393,400	0.01%	**2,000**
TW Taiwan	189	208,153	0.09%	**2,000**
UK United Kingdom	49,387	2,539,297	1.94%	**6,000**
US United States	202,120	6,096,111	3.32%	**10,000**
ZA South Africa	180	369,599	0.05%	**0**

[59] Nele Rietmann, Theo Lieven, *How policy measures succeeded to promote electric mobility e Worldwide review and outlook* in Journal of cleaner production p. 69 <ELSEVIER> 2018

[60] The traffic regulation variable is a number between 0 and 3. The highest evaluation was assigned to the most virtuous states regarding environmental policies.

Table 2.2.2)

Country	Traffic Regulation	Charging Stations total	Highway km	Stations per highway km	National PP
AU Australia	**0**	476	1,700	**0.28**	**98.8**
BE Belgium	**0**	1,651	1,763	**0.94**	**87.6**
BR Brazil	**0**	100	11,000	**0.01**	**29.5**
CA Canada	**1**	5,000	16,900	**0.30**	**91.3**
CH Switzerland	**0**	3,869	1,361	**2.84**	**114.8**
CN China	**2**	141,254	97,355	**1.45**	**27.8**
DE Germany	**0.2**	17,953	12,845	**1.40**	**100.0**
FR France	**0**	15,843	11,392	**1.39**	**83.3**
HK Hong Kong	**0**	1,505	100	**15.05**	**89.2**
IN India	**0**	353	1,208	**0.29**	**10.9**
IT Italy	**0.5**	2,228	6,661	**0.33**	**70.2**
JP Japan	**0**	23,250	7,383	**3.15**	**80.5**
KR Korea	**0.5**	1825	4,044	**0.45**	**63.7**
NL Netherlands	**0**	30,493	2,808	**10.86**	**97.9**
NO Norway	**3**	9,633	664	**14.51**	**131.9**
RU Russia	**0.5**	190	1,400	**0.14**	**39.4**
TW Taiwan	**0**	400	1,335	**0.30**	**60.0**
UK United Kingdom	**1**	13,524	6,016	**2.25**	**85.3**
US United States	**1**	45,225	75,008	**0.60**	**116.9**
ZA South Africa	**0**	90	1,927	**0.05**	**22.5**

Source: Nele Rietmann, Theo Lieven, *How policy measures succeeded to promote electric mobility - Worldwide review and outlook* in Journal of cleaner production, p. 69, <ELSEVIER> 2018

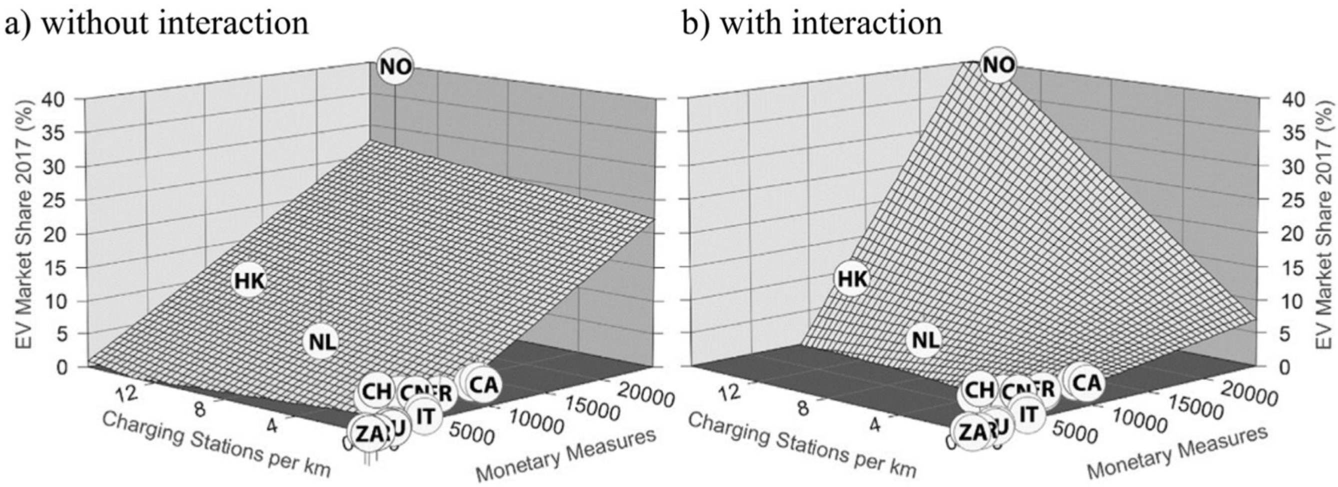
The results with 2017 data fully agree with the model reported in the previous paragraph and provides more accurate results. The main coefficients are all statistically significant:

- $\beta_{MonetaryMeasures} = 0{,}27$ with p < .01
- $\beta_{TrafficRegulations} = 0{,}37$ with p < .001
- $\beta_{Infrastructure} = 0{,}32$ with p < .001

the model's R^2 is equal to 0,817 which means that almost the 82% of the EV market share variation is explained by the data.
One of the most interesting result achieved in this study concerns the insertion of another variable: the $\beta_{Interaction}$[61] which in the second model tested results equal to 0,37 with p < .001.
These variable results to be so impacting that the coefficient for traffic regulation loses almost all of its effect: $\beta_{TrafficRegulations} = 0{,}09$ with p < .01; moreover, for the second model, the R^2 increases from 0,817 to 0,96.

[61] The interaction refers on how monetary measures and the presence of well distributed infrastructures amplify their effect on the dependent variable.

To further confirm the fundamental influence of incentives and infrastructures on EV market share Rietmann and Lieven[62] fitted a 3D plots of market share regression on monetary measures and charging stations per km:



The linear model in figure a) do not fit the data as well as the plot b) does, in fact, including the interaction coefficient in the calculation, the points tend to lean adequately on the surface of the figure.
The main problems with the linear model in the figure a) are given by the outliers which alter the model fitting[63]. The SEM analysis was repeated removing the outliers (Norway, Netherlands and Hong Kong)[64]; despite this data removal the model explains more than the 87% (R^2 = 87,1) and the overall results remain consistent with every assertion that has been stated so far.
Considering all these variables, the model could be expanded by inserting information about the concentrations of independent houses (not apartments) present in a state.
It is reasonable to think that the presence of a private charging system, possibly present in homes but not in apartments, can strongly influence the propensity to purchase an electric vehicle, especially if at the moment the public charging systems are not adequately developed, and in any case, not fast.
As a result, a concomitant development of monetary incentives and efficient infrastructures is essential to guarantee an adequate basis for a worldwide spread of EV.
The “interaction" effect computed in the previous model occurs strongly in countries where a substantial level of market share has been already achieved.

[62] Nele Rietmann, Theo Lieven, *How policy measures succeeded to promote electric mobility e Worldwide review and outlook* in Journal of cleaner production p. 71 <ELSEVIER> 2018
[63] Despite Netherlands has one of the most developed charging infrastructure system among the pool, the Dutch government interrupted some monetary incentives in 2017 thus creating a reversal in the growth trend and therefore altering the data.
[64] Nele Rietmann, Theo Lieven, *How policy measures succeeded to promote electric mobility e Worldwide review and outlook* in Journal of cleaner production p. 71 <ELSEVIER> 2018

In nations where the EV market share is underdeveloped, as Rietmann and Lieven quotes[65], occurs the "chicken-and-egg-problem" that is, the impossibility of investing profitably in infrastructures for the electric mobility without an adequate users base, but at the same time the impossibility to develop a widespread user base without an efficient infrastructure system. In this situation, the subjects who are in the position to take the first step are governments institutions, which must commit to implement policies in order to encourage electric mobility even if in the short term the investments will be not profitable; indeed, the objective should not be only the short-term profitability but primarily the climate targets set by supranational governments.

[65] Nele Rietmann, Theo Lieven, *How policy measures succeeded to promote electric mobility e Worldwide review and outlook* in Journal of cleaner production p. 71 <ELSEVIER> 2018

2.3 Renewable energy and crude oil relation

The purpose of the following analysis is to study the relations between renewable energy market and crude oil price. The decision to analyze data related to renewable energy sources and not to the electric vehicles directly is due to the data's scarcity and unreliability. The EV market has experienced an important development only in the recent years and for this reason the attempt to build an explanatory model could lead to obtain results that, even if statistically significant, probably would not be realistic. All the information to be included in the model would be obviously historical and related to an extremely limited period of time, indeed before the last five years[66] the EV market share was trifling[67] and also the covid-19 pandemic crisis has altered the natural course of economic progress in the last 16 months.

The optimal methodology to investigate the relation between crude oil and EV would be a model that incorporates the crude oil price[68] and renewable energy data; as previously reported, the renewable energy market is strongly correlated with the EV market share, moreover it is essential to underline the concept that without energy production by renewable sources far less polluting, electric mobility has no reason to exist since the energy necessary to power the EV, if produced by petroleum derivatives, does not bring substantial environmental benefits which instead must be the main objective for the development of green mobility. Fossil fuels are the primary source for current energy production and, in the case of crude oil with his derivatives, for powering cars.

The following model[69] analyze the main factors that influence the renewable energy use.

The study aims to show how some variables, including the crude oil price during periods of low evaluation, are related to renewable energy and therefore also connect to the EV market; indeed, it is reasonable to think that if the price of oil tends to decrease, the production of RE will also undergoes a contraction due to the reason that these two sources of energy are substitute goods. The results proposed in table 2.3.1) are the model's outputs constructed with the renewable energy world consumption as a dependent variable.

[66] Before Q2 2016

[67] In the first quarter of 2015, the overall sales for EV's and PHEV's was 39.000 in Europe, against the 237.000 of 2020's Q1: See *Sales volume of electric vehicles in Europe 2014-2020* Published by Statista Research Department, Sep 1, 2020

[68] In periods of low prices.

[69] Eder L.V. et al., *World energy market in the conditions of low oil prices, the role of renewable energy sources* in Energy Procedia, p. 115 <ELSEVIER> 2018

Table 2.3.1)

Variable	Pooling	Random	Fixed
(Intercept)	-20.86***	-15.32***	
Logarithm (Production to consumption ratio)	-0.09**	0.10	-0.23*
Logarithm (Oil prices 2nd lag)	1.39***	1.15***	1.05***
Logarithm (Corruption index)	2.63***	1.51***	1.32***
Logarithm (Share of R&D in the GDP)	-0.59***	0.64**	1.10***
R^2	0.39	0.50	0.54
Adj. R^2	0.38	0.50	0.49
F-statistic	63.22	101.26	106.53

Three different regression models were constructed: a pooled regression, a fixed effect model and a random effect model.

Looking at the R^2 coefficients the most explanatory results are those related to the fixed effect model[70], this assumption is further confirmed by the F-Statistic which indicates the model's [71] significance.

The model is constructed as follows[72]:

$$ln(RESC) = -0{,}23 * ln(PC) + 1{,}05 * ln(Oil) + 1{,}32 * ln(CI) + 1{,}10 * ln(RDGDP)$$

where RESC is the renewable energy consumption, PC is the ratio of production to consumption, Oil is the price of crude oil with two lags[73], CI is the corruption index, RDGDP is the share of R&D in GDP of each country[74].

[70] The fixed effect (FE) regression model is used when it is not possible to assume the absence of parameters' serial correlation, that is: the presence of correlation between the same variable observed repeatedly over time; it is reasonable to think that for this type of data the values observed at time t are influenced by the observations at $t-1$ and that affects the values at $t+1$.
Using an adjustment, the FE model allows to obtain an estimation of the time-varying parameters.
To the contrary the random effects (RE) model assumes the absence of autocorrelation and by means of generalized least squares (GLS) it applies the calculation.
If the hypothesis of absence of autocorrelation is violated the Random effects model's estimator will be distorted
[71] The regression's F-Statistic tests the joint hypothesis that all the coefficients are equal to zero.
It is not one of the most solid tests to verify the overall reliability, indeed, in a multiple regression model, even if only one of the coefficients is different from zero the test will give a positive result on the model significance.
However, being the test a ratio between two independent variance estimations, to a higher value of F we associate a greater reliability of what model explains.
[72] Eder L.V. et al., *World energy market in the conditions of low oil prices, the role of renewable energy sources* in Energy Procedia, p. 115-116 <ELSEVIER> 2018
[73] Lag at two years.
[74] The logarithmic transformation of variables allows to obtain a linear relationship and, in addition, it has the advantage that variables expressed in this form can be interpreted as percentage variations, such as those reported

The main results show a significant positive correlation between the renewable energy consumption and the crude oil price at the second lag, that is: if we assume the model reliable enough to make forecasts, an increase of crude oil price in 2021 by 1% will directly cause a growth in the RE source consumption by 1,05% in 2023 with all the other variables fixed.

The second important result concerns the coefficient related to the fraction of R&D and GDP.

Starting from 2014 the fossil fuel industry has undergone a substantial restructuring which improved the operational efficiency allowing to maintain excellent profits with lower selling prices; this changes led to a stagnation of the RE development[75] demonstrating how technological innovations plays a fundamental role in the energy industry; indeed, consistently with the result reported in the previous chapter, substantial investments in technological research influence positively the renewable energy production and consumption.

At the moment the RE efficiency is not high enough to guarantee production levels adequate to meet the demand, the alternative energy sources represent only a complement and not a direct substitute.

However, there are evidence that some of the major oil companies are adapting their business strategy to prevent threats deriving from the energy transition. In fact, firms like Royal Dutch Shell and the Italian multinational company Eni are orienting their investment choices towards the transition to sustainable energy turning more into energy companies than oil[76].

For example, the Royal Dutch Shell company started a new division for the "New Energies", in order to diversify their activities, focusing on hydrogen, electric vehicle charging, biofuels and renewable power[77].

The possibility to encourage this change can bring further economic benefits for the large companies above mentioned, as well as environmental advantages, avoiding excessive competition between different players and orienting the investment choices of polluting companies towards sustainable business models.

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[75] Eder L.V. et al., *World energy market in the conditions of low oil prices, the role of renewable energy sources* in Energy Procedia, p.116 <ELSEVIER> 2018

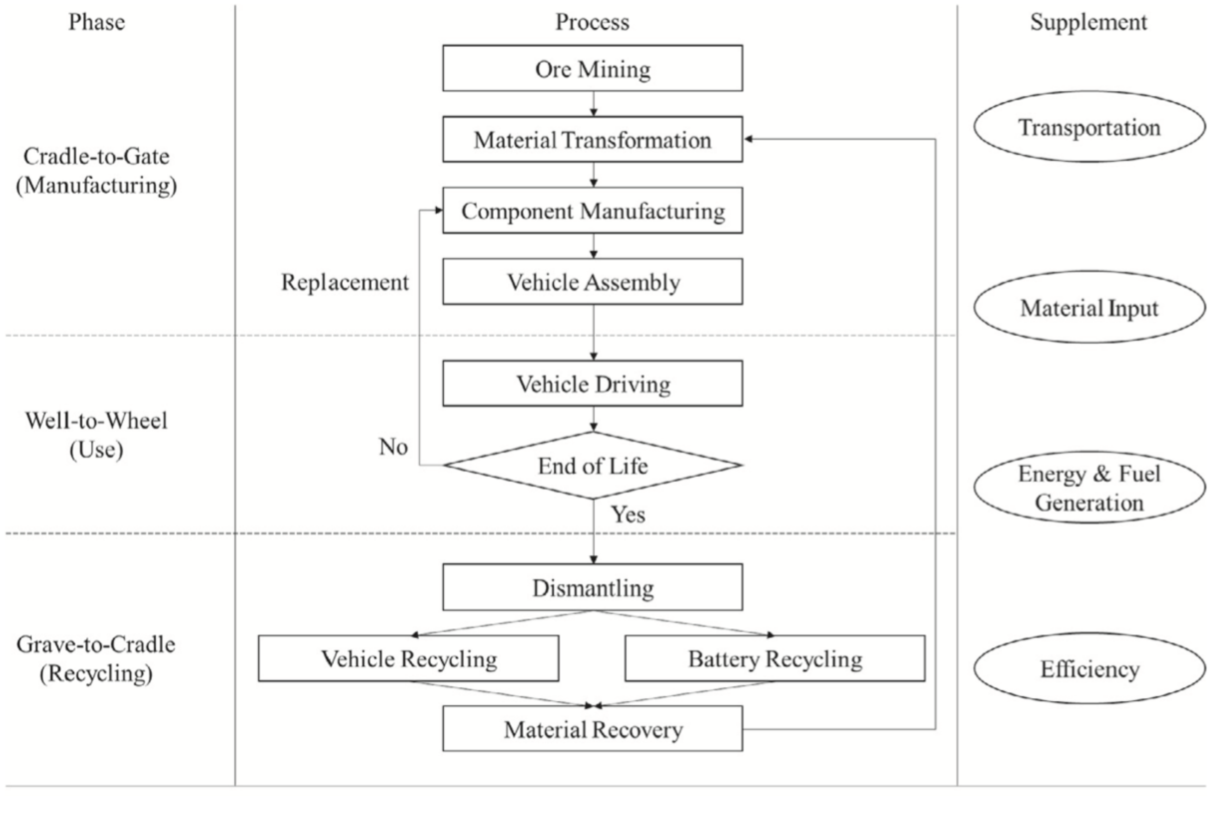
[76] Pickl J. Matthias, *The renewable energy strategies of oil majors – From oil to energy?* in Energy Strategy Reviews, p. 1 <ELSEVIER> 2019

[77] Ibid, p. 2

2.4 Environmental benefits

The substantial purpose that is guiding governments' choices to the massive adoption of EV concerns the objective of reducing the carbon dioxide emissions and other fossil fuels combustion wastes. The emissions produced can be divided in two major subgroups: direct emissions and life cycle emissions. The first category concerns the pollutions produced by cars during the practical use, that is, the waste components of combustion for the ICE cars and the electricity consumed by the EV. The second category mentioned concerns the emissions caused during the production of parts that compose the entire car and the subsequent assembly phases. Thinking of electric cars as zero-emissions vehicles is incorrect: indeed, a large portion of co_2 emissions come from the manufacturing and disposal processes of the components, not just from use.

The following scheme[78] shows the entire car's lifetime, dividing the whole period into three main phases: CTG (Cradle-to-Gate) related to procurement, production and assembly activities, WTW (Well-to-Wheel) "the road period" and GTC (Grave-to-Cradle) related to the dismantling and recycling activities.



Source: Qiao et al., *Life cycle greenhouse gas emissions of Electric Vehicles in China: Combining the vehicle cycle and fuel cycle*, in Energy, p. 225, <ELSEVIER> 2018

[78] Qiao et al., *Life cycle greenhouse gas emissions of Electric Vehicles in China: Combining the vehicle cycle and fuel cycle*, in Energy, p. 223, <ELSEVIER> 2018

Qiao et al. have developed a formula to calculate the emissions of the two types of vehicles[79] discussed so far: ICE and EV;

$$E_{LC} = (E_a + \Sigma E_{M,i}) + E_d + (E_{vr} + E_{br} + \Sigma E_{MR,i}) - E_s$$

where E_{LC} is the overall GHG emission, E_a is the GHG emission of components and vehicle assembly, $E_{M,i}$ indicates the emissions of the manufacture of material i, E_d indicates the driving emissions, E_{vr} and E_{br} respectively indicate the emissions of materials recycling (including dismantling), $E_{MR,i}$ indicates the emissions deriving from the material *i* recovery process, E_S indicated the reduction of GHG emissions trough the reuse of materials.

The main results for 2015 are reported in Table 2.4.1)[80].

Table 2.4.1) Life cycle GHG emissions of an EV and ICEV.

GHG emissions (kg-CO_2eq)	CTG		WTW		GTC	
	ICEV	EV	ICEV	EV	ICEV	EV
In 2015						
Vehicle (without battery)	10,486	9819	37,722	25,593	1777	1714
Traction battery	/	3165			/	693
Subtotal	10,486	12,984	37,722	25,593	1777	2407
Total (ICEV)	49,985					
With recycling benefits	44,730					
Total (EV)	40,983					
With recycling benefits	34,023					
In 2020						
Vehicle (without battery)	9744	9025	37,722	20,062	1486	1390
Traction battery	/	2971			/	666
Subtotal	9744	11,996	37,722	20,062	1486	2056
Total (ICEV)	48,952					
With recycling benefits	44,028					
Total (EV)	34,113					
With recycling benefits	27,479					

Overall, the main results show that ICE vehicles, with 49,985 kg-CO2-eq, are more polluting than EV with 40,983.

In 2020 this gap increased further[81] making electric car even less polluting thanks to the renewable energy production and improving energy efficiency.

[79] Qiao et al., *Life cycle greenhouse gas emissions of Electric Vehicles in China: Combining the vehicle cycle and fuel cycle*, in Energy, p. 225, <ELSEVIER> 2018

[80] Ibid. p. 227

2.5 Conclusion

One of the main conclusions reached with the analysis in the second chapter confirms that the main barrier to allow a massive development of electric cars is the purchase price which at the moment is too high for the average salary. The ICE vehicles still offer an excellent price-quality ratio which allows this product to remain competitive; however, the electric mobility offers several advantages: the first of all is the one that has been discussed for a long time: the GHG environmental impact.

To ensure that the electric car market could develop in a decisive way, effective policies are required. The interventions can be of various and have different effects. For example, traffic regulations or parking incentives do not seem to be valid enough to have a significant effect.

The analysis has shown that the most effective interventions are infrastructural and monetary policies, this last one realistically represents the key concept as they can intervene directly on the monetary cost that a buyer has to bear during the purchase process.

Indeed, the TCO calculation reported for different models of car and their electric equivalent, has shown that ICE vehicles remain the cheaper alternative but, considering that EVs have much higher margin for improvement in terms of efficiency and costs, they can become a growing share in the automotive market.

In the second part of the chapter were analyzed the relationships between renewable energies, therefore indirectly EVs, and the crude oil price. The results show a fair positive relation between the crude oil price and the renewable energy consumption: in fact, in accordance with the predictive power of the proposed model, a 1% reduction in the price of oil would result in a 1.05% reduction in sustainable energy consumption after two years. This situation can represent a strength for oil companies which could choose to lower prices in order to slow down the development of the RE, and therefore continuing to sell crude oil. This particular circumstance turns out to be only a hypothesis that, in this precise historical moment, does not represent a concrete threat being the renewable energies only a complement to fossil fuels without the possibility of replacing them totally.

Regards to the environmental impact, the analysis reports the presence of various benefits, among which the most important and much discussed: the GHG emissions reduction.

The analysis of the total emissions showed positive results for electric cars which are overall less polluting. The greatest part of emissions occurs during the road phase of the vehicle and since there are highly margins of improvements regarding: the weight of the batteries, the efficiency of the electric motors and the kinetic energy recovery systems, there are reasons to think that the environmental benefits associated to the use of EVs can significantly increase in the next few years.

Considering that the technological development of ICE has already reached high levels and the margins of improvements are reduced, it is possible that the differences between the two types of vehicles in terms of efficiency, economy and environmental impact will reduced to the point that in few years electric cars could be the optimal alternative for the private mobility.

Chapter 3: EV supply chain

Introduction

In the previous chapter the reasons why electric cars have not yet penetrate the market satisfactorily were analyzed. Contrary to some exogenous characteristics such as infrastructures, one of the most manageable key factors for profitability in the electric cars production is the selling price which, by means of investments in selected companies, can be significantly reduced.

Considering the forecasts reported in the previous chapters about the expected expansion of the EV market, cars manufacturers have the possibility to make prospective investments that can potentially turn out to be bargain in few years.

The following chapter is aimed to identify how the price of electric cars can be reduced and what are the alternatives to make the supply chain more efficient. Initially, the comparison of the cost structure between the two typologies of cars, is presented: a classic ICE car and an electric car. The results show that there is a strong similarity in the costs of almost all components with the only exception for batteries and powertrain which are significantly more expensive in EVs.

The main causes of such high costs can be attributed both to improvable technological production processes and to the high costs of raw materials, such as lithium and cobalt, essential for the construction of Li-Ion batteries and electronic components.

The study continues showing the structure of the supply chain for the production of electric cars.

The hypotheses subsequently proposed concern the possibility of investing in the supply chain by means of backward vertical integrations or by investing in companies that deal with the recycling and waste management of EVBs. Regarding the first alternative, the possibility to have more control over the suppliers is a key factor to produce electrical components such as EVBs; in fact, the possibility of coping supply shocks, as occurred for semiconductors in 2021, is an aspect of great value considering the expected growth of the electric automotive sector. However, among the hypotheses proposed, it is reasonable to think that the best investment alternatives may derive from M&A operations with companies operating in the waste management and recovery of rare metals. Indeed, the mining industry is characterized by great criticalities. Specifically, many operational threats are linked to organizational, geopolitical and technological sophistication, combined with a high competitive environment. Furthermore, in the backward supply chain it is more likely to find companies that are already quite large and consolidated for which a higher premium should be paid. Because of these reasons, one of the most attractive alternatives now appears to be a potential investment in the recycling business of materials such as lithium, cobalt, nickel and other.

The results of the analysis shown below demonstrate how a good management of the EVBs can lead to a reduction in costs up to 10%[88]. Some public companies that operate in the scraps management industry have very interesting visions and technical knowledge that can prove to be an excellent investment in the long term.

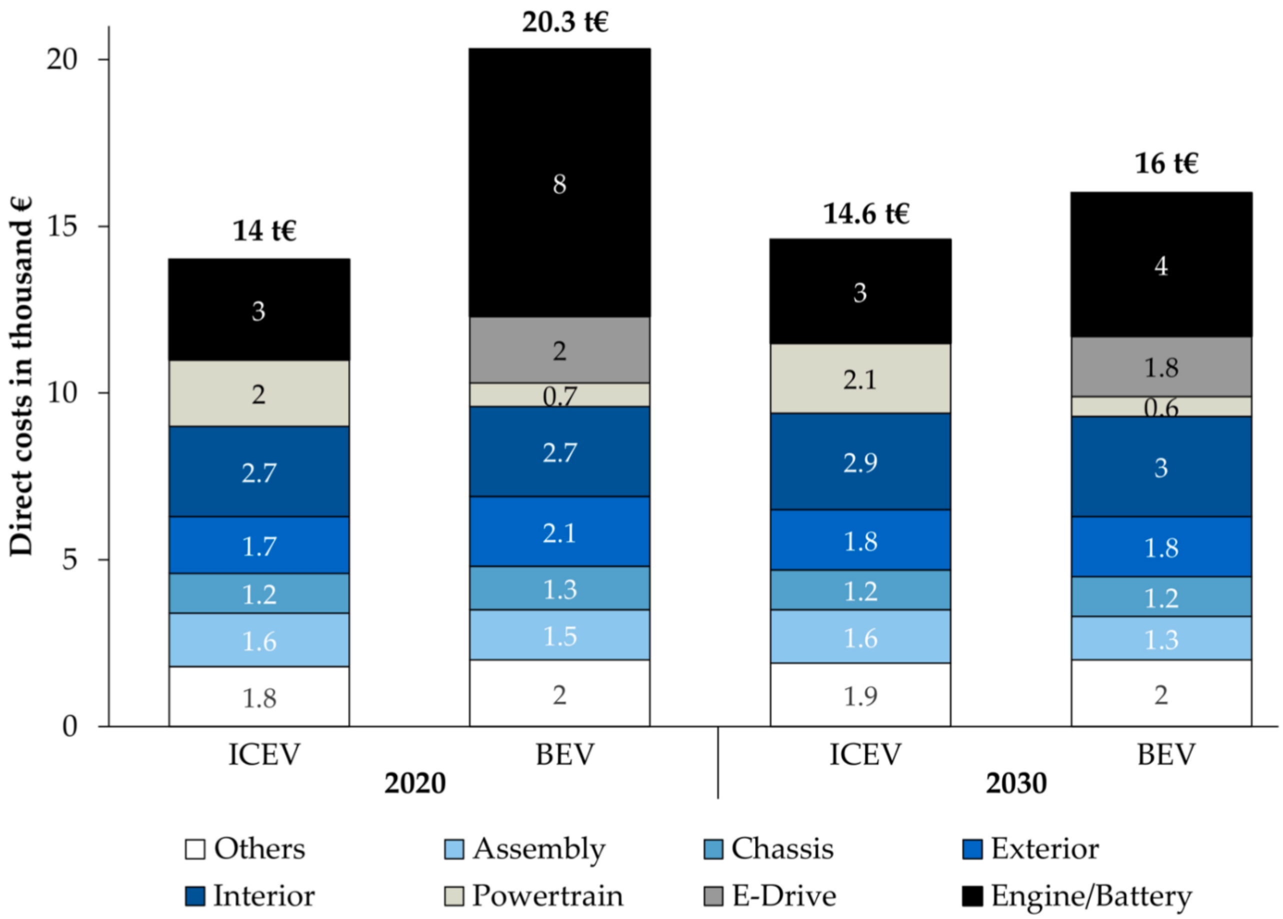
The objective of this chapter is to identify which companies may be the most attractive target for an electric car manufacturer which desire to integrate into their business the recycling processes of rare materials in order to obtain circular and sustainable production, economically more convenient and in accordance with the increasingly requested ESG criteria.

[88] It must be considered that the assessments are carried out based on today's economic results and that in the near future the development of technological recovery processes may further increase the economic benefits.

3.1 Electric vehicle's cost structure

It has been shown that one of the main barriers to buy an electric car is the price; the cost/premium ratio is currently not competitive compared with the ICE cars. At the moment, electrical components are not yet optimized so, electric cars do not provide an economic alternative for consumers. The production of electric cars involves completely different components compared to the classic vehicles, primarily the engine. The following analysis will show the cost structure of EVs and ICE cars. The following diagram[89]represent the average cost of the various segments that constitute the vehicle.

Table 3.1.1)



From the graph it is very intuitive to understand that the costs discrepancy between the different car typologies derives mainly from the batteries.

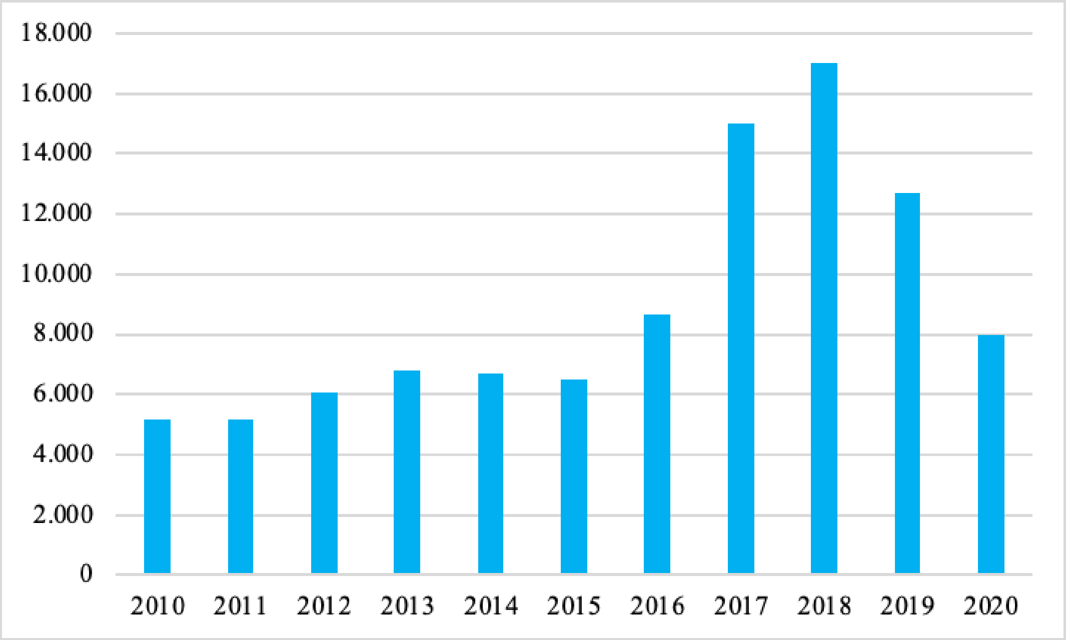
The causes of this price level depend on raw materials, in particular lithium.

89 König A. et al., An Overview of Parameter and Cost for Battery Electric Vehicles, p. 2 <World Electric Vehicle Journal> 2021

During the last decade the cost of lithium has firstly undergone a growth and then a reversal in the trend (also due to the covid-19 pandemic crisis), however remaining stable on over $8000 per metric ton. Table 3.1.2 shows the historical data related to the price of the raw material.

Table 3.1.2)

Average lithium carbonate price from 2010 to 2020 (in U.S. dollars per metric ton)



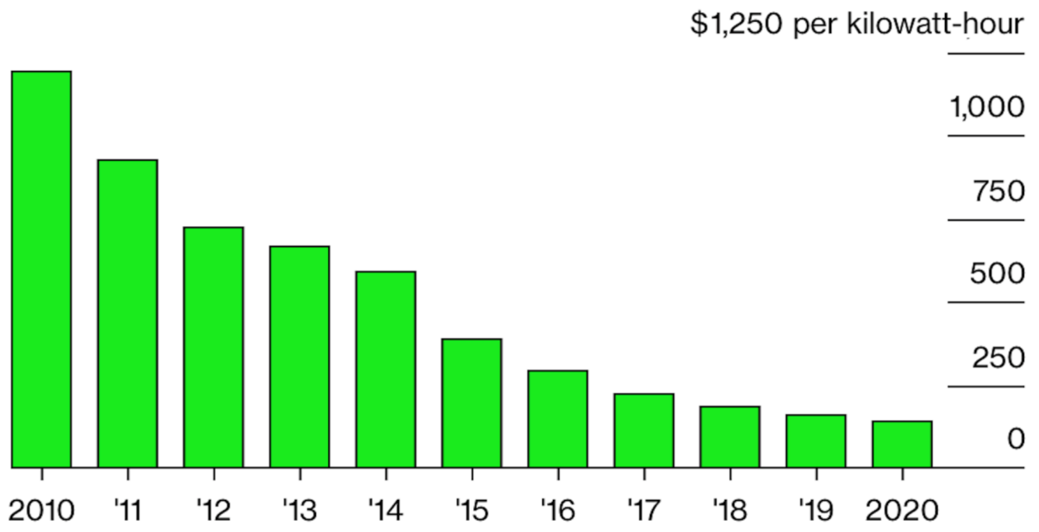
Source: M. Garside, *Lithium carbonate price 2010-2020, <STATISTA> 2021*

Despite the increasing price level of lithium, the cost of EVBs has drastically reduced over the last decade[90]. The main reason for this price reduction is related to the technological improvement that lithium-ion batteries have undergone, specifically characteristics like volumetric energy density and gravimetric energy density which contribute substantially to the increase of the overall performances[91]; however, even if the price is much more reasonable than in the past, the cost for a single battery pack remains high. For example, a battery with good performance[92] in term of horsepower and driving range, which allows customers not to have the "range anxiety", has a price above $10,000. The following table shows the declining trend in Li-ion battery price per kW/h.

[90] BloombergNEF 2020 Lithium-ion Battery Price Survey
[91] Ziegler S. Micah et al. *Re-examining rates of lithium-ion battery technology improvement and cost decline* p. 1636 <Energy and Environmental Science> 2020
[92] A 75 to 85 kW/h Li-ion battery

Table 3.1.3)

Lithium-ion battery price, volume-weighted average, all sectors (real 2020 dollars)



Source: BloombergNEF 2020 Lithium-ion Battery Price Survey

In the near future the main OEMs' objective should be to further reduce the cost of batteries for EVs in order to lower the overall average cost per car. The main strategies should consist of two fundamental points: investing in technological research (as previously clearly reported) and improving the efficiency of the supply chain. The 2021 semiconductor shortage is an example of the critical issues related to the production of electronic components which can lead to losses linked to supply chain shocks. In 2021, several car manufacturers such as Toyota had to adjust their production output due to the supply shortage[93].

The crisis originated from a very high increase in demand for electronic devices that occurred during the covid-19 pandemic, at the same time the global economic crisis impacted negatively the production volumes of electronic components, this combination led to a strong divergence between supply and demand which has forced several companies to limit their production.

Even if lithium is currently not specifically among the materials that fail to meet demand, this crisis represents a critical issue for the automotive market for two reasons. Primarily, the nature of the crisis underlines the importance of electronic components that production companies cannot guarantee.

[93] The Wall Street Journal, *Toyota to Cut Output as Chip Shortage Finally Catches Up to It*, Sean McLain 19 August 2021

Secondly, the automotive production has been put on standby and the slowdown could last for many months[94].

Similar situation could concern the supply chain of materials such as lithium or cobalt in the coming years. For these reasons, considering the ever-increasing demand for raw materials, which could lead to a new rise in the price of lithium, it is essential to optimize the production processes also by means of investments in companies that work in the business of extraction and processing of rare metals, essential for the production.

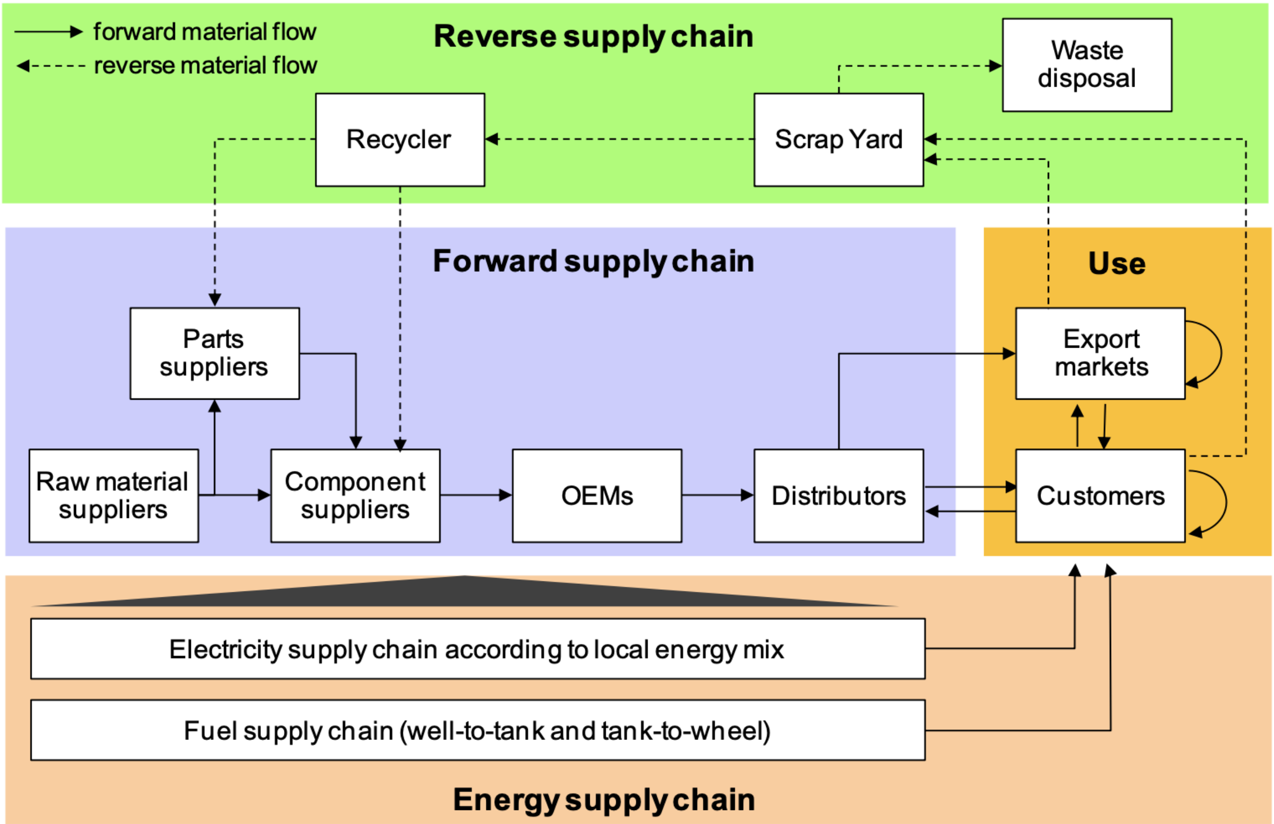
[94] The Wall Street Journal, *Intel CEO Says Chip Shortage Could Stretch Into 2023*, Asa Fitch 22 July 2021

3.2 The supply chain

The supply chains process proposed can be divided in two difference courses: the forward and the reverse supply chain[95]. Both are extremely important as they contain potential for integrations, with possibilities to increase profits, reducing the environmental impact.

The following table[96] shows the structures of the supply chains involved in the EV market.

Table 3.2.1)



The graph shows the direct link between components suppliers and the car manufacturers which in this case are part of the OEMs group.

Subsequently distributors are directly connected to the OEMs. However, it is reasonable to think that, for the automotive sector, the distribution activity is not very separate from the manufacturing divisions even if there are many unofficial dealers. In these conditions the main opportunities of integration in the "Forward supply chain" derives from backward mergers or acquisitions operations.

The three categories of suppliers placed immediately before OEMs in the forward supply chain, namely: raw materials suppliers, parts suppliers and components suppliers, represent a group of stakeholders strictly

[95] H.O. Günther et al., *The role of electric vehicles for supply chain sustainability in the automotive industry* in Journal of Cleaner Production, p. 222 <ELSEVIER> 2014.

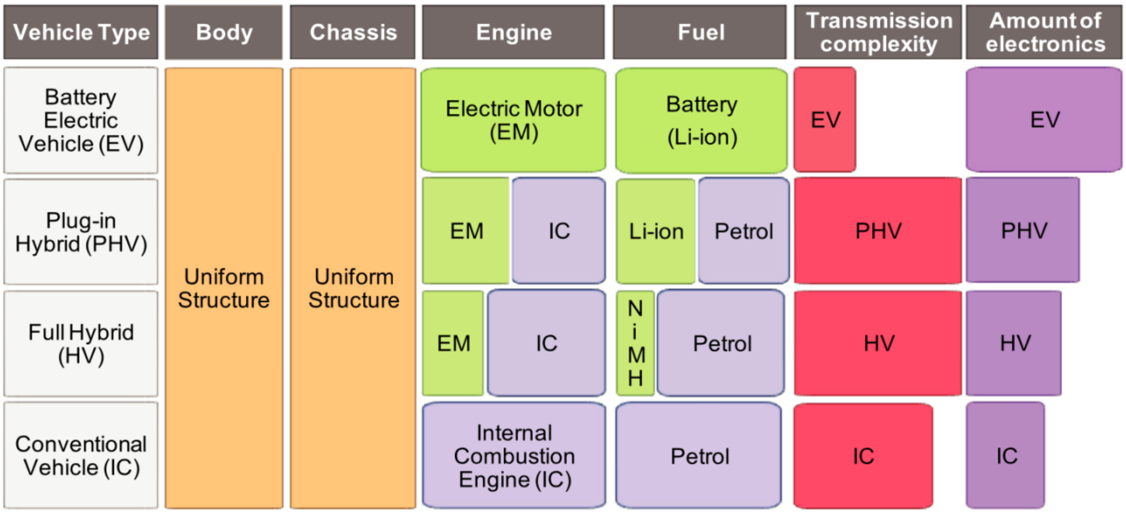
[96] Ibid.

connected to the manufacturing division and with whom fundamental contracts are established for ordinary operational activities.

The semiconductor shortage of 2021 is an example of how these groups of suppliers play a critical role for the production stability, both in the automotive market but also in the technology industry.

Table 3.5[97] shows the composition of the vehicle depending on the powertrain. Electronic components represent a higher percentage in fully electric cars.

Table 3.2.2)



The major car manufacturers, that are developing projects for electric mobility, could move towards integration,along the backward supply chain, with companies that deal with primary processes for the production of particular components.

The most interesting opportunities can be represented by companies that are not strongly developed and consolidated but with good growth prospects, for example companies operating in the mining industry or highly specialized components manufacturers.

For example, in 2019 Tesla Inc. decided to expand their business and completed the acquisition of Maxwell Technologies, Inc[98]. This operation could be an intelligent strategy to increase the technical know-how on electrical power management for electric vehicles.

The acquisition represents a backward vertical integration, indeed Maxwell Technologies, which previously represented only a components supplier for Tesla, is now part of the company and can contribute directly to the business development benefiting from the synergies created.

[97] H.O. Günther et al., *The role of electric vehicles for supply chain sustainability in the automotive industry* in Journal of Cleaner Production, p. 224 <ELSEVIER> 2014.

[98] Tesla official Web site (Press Releases), *Tesla Completes Acquisition of Maxwell Technologies*, <Global Newswire>, 16 May 2019

The other activity that could be integrated is included in the “Reverse supply chain”; specifically, the recycling processes which, in addition to the environmental impact reduction, can reduce significantly the production costs. Recent studies[99] have shown that the processes of recycling and reuse of the main parts[100] that compose the EVB can avoid the purchase of new components, guaranteeing an overall reduction in costs.

[99] Alfaro-Algaba et al., *Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing* in Resources, Conservation & Recycling <ELSEVIER> 2019.
[100] Lithium cells.

3.3 Recycling activity: Environmental and economic advantages

It has been shown that the fundamental component to work on in order to reduce the total price of the EVs is the battery. As previously noted, in the next future the technological development will play a fundamental role for the efficiency improvement together with costs reduction. However, some economic opportunities are already present in the supply chain structure shown with table 3.3, specifically in the scrap yard and recycling phases. The scraps management can prove to be a profitable business in both economic and environmental terms. The activity necessarily leads to dividing the components of “end-of-life" vehicles in two different categories: waste to disposal and reusable components.

Alfaro-Algaba M. et al.[101]quantified economically the processes in the reverse supply chain.

The study is focused on three different methodologies that can be used during the disassembly phase of an EVB[102]: the R.E.U (reuse), R.E.M (remanufacturing), R.E.C (recycling).

These methodologies are listed in descending order by retention status, that is: the REU implies that most of the components are in excellent condition and can be disassembled and reused, the REM implies that the components are in slightly less good condition but still recoverable, lastly the REC methodology implies poor conditions for components that should be mostly recycled.

The calculation is based on the structure of a relatively standardized battery. The model considered belongs to the Audi A3 Sportback e-tron hybrid. The battery is composed of 8 modules with 12 cells[103] each.

The economic results deriving from the processes of reuse and recycling of valuable components are divided into three different simulations. The first scenario implies that the battery pack is severely worn and that it is not suitable for recycling, so none of the modules can be disassembled and recovered. The second one implies that an "average" measure of modules can be recovered, specifically the half of the total modules, so four on eight. The third simulation evaluates the most optimistic scenario which implies that all the modules are in good condition and therefore can be disassembled and recovered.

The economic results (y_1) are calculated as the difference between the total revenue, deriving from the recycling activity, and the disassembly costs:$y_1 = ID - CD$. Similarly, the environmental results (y_2) are calculated as the difference between the environmental impact avoided thanks to the activity of recycling, reuse or remanufacturing, and the environmental impact deriving from the disassembly processes: $y_2 = IME - IMC$.

[101] Alfaro-Algaba M. et al., *Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing in Resources,* Conservation & Recycling, <ELSEVIER> 2019

[102] Audi A3 Sportback e-tron Hybrid Li-ion battery

[103] The cells are one of the most valuable components of the battery since they are the fulcrum of the electrical energy storage activity.

The results are reported in the following graphs[104].

Table 3.3.1)

Scenario 1; 0 modules recoverable

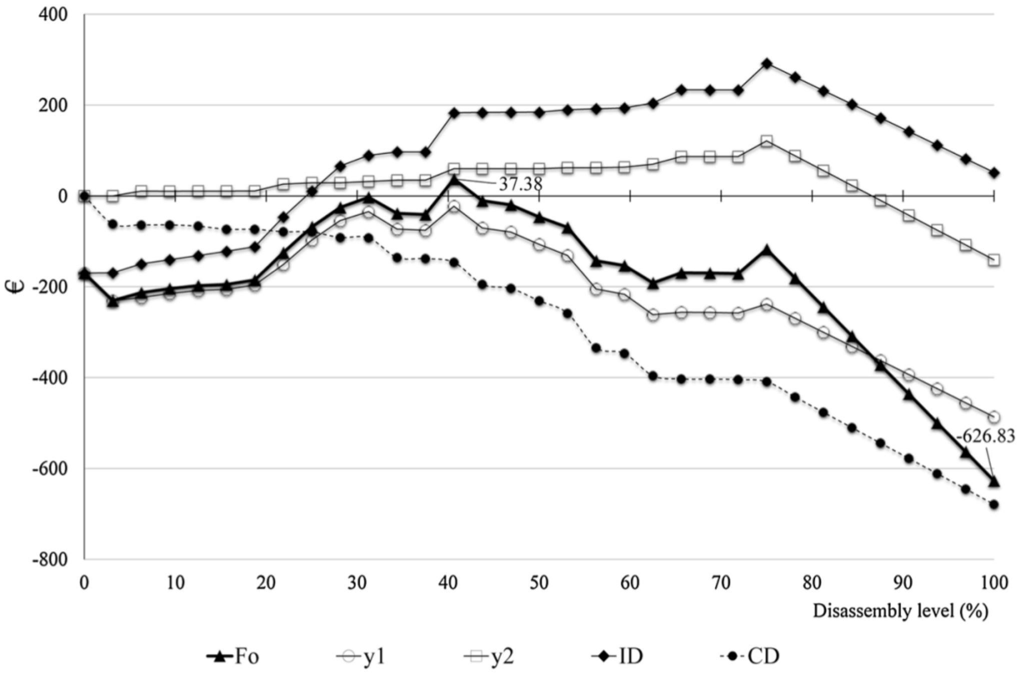
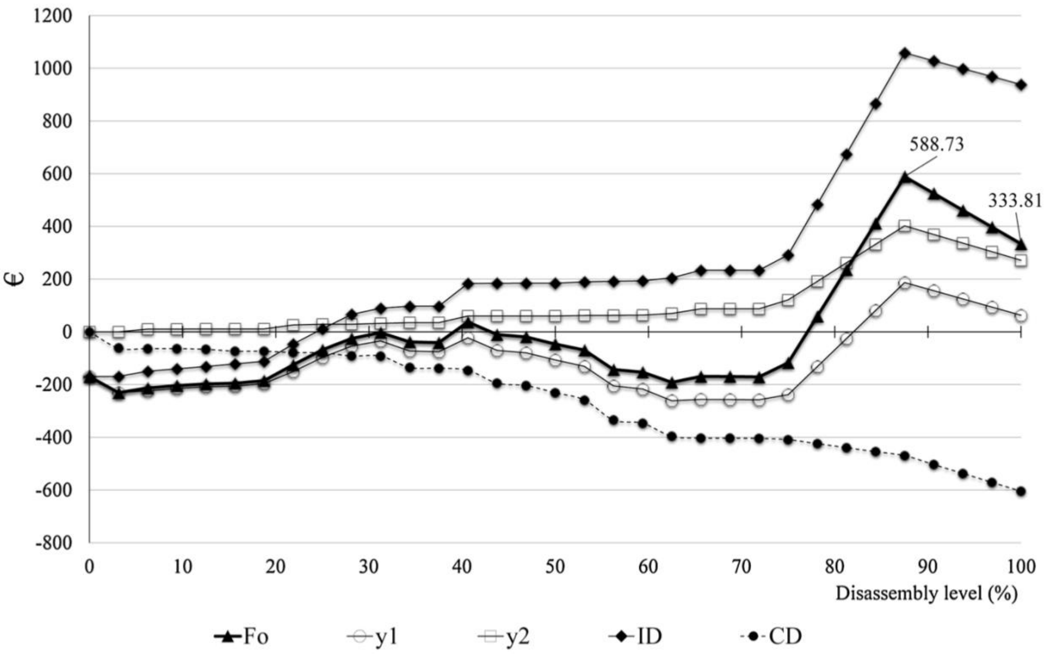


Table 3.3.2)

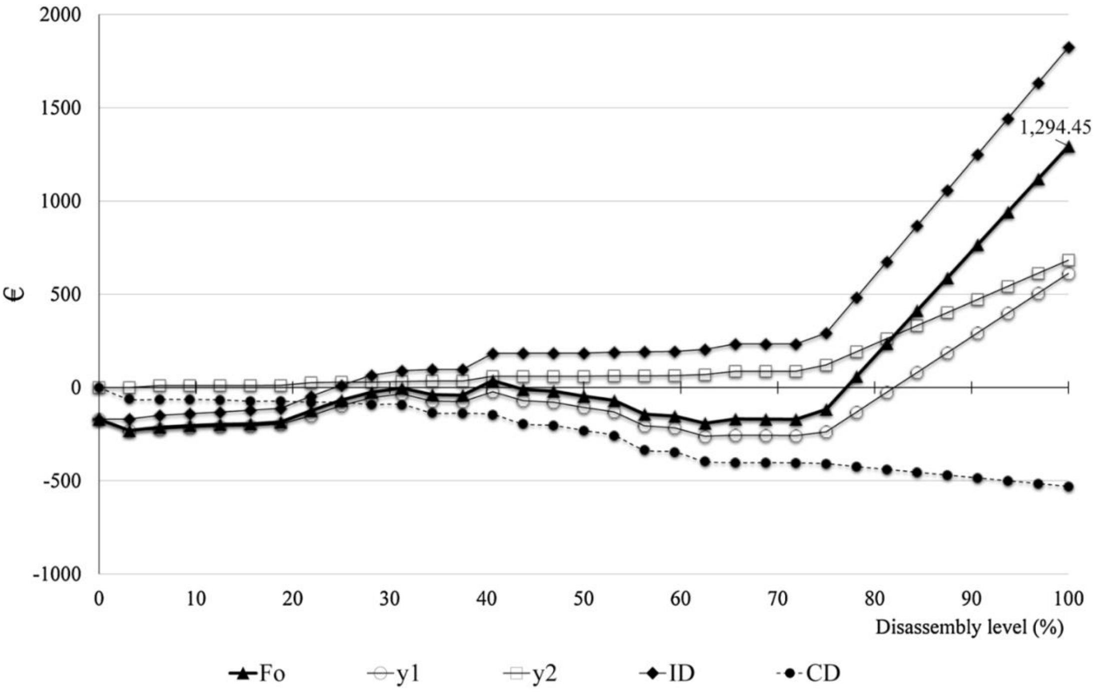
Scenario 2; 4 modules recoverable



[104] Alfaro-Algaba M. et al., *Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing in Resources*, Conservation & Recycling, p. 8-9 <ELSEVIER> 2019

Table 3.3.3)

Scenario 3; 8 modules recoverable



The battery's disassembly levels are ordered on the abscissa axis of the graphs. The following table[105] shows the disassembly levels corresponding to the components that can be recovered at that level. The most valuable components of the disassembly sequence are the cells, cataloged with the numbering 16-17. The presence of eight of these in the whole battery can be verified according to what was previously mentioned.

[105] Alfaro-Algaba M. et al., *Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing in Resources*, Conservation & Recycling, p. 6 <ELSEVIER> 2019

Table 3.3.4) **Disassembly level according to disassembly sequence.**

Disassembly sequence	Disassembly level (%)	Disassembly sequence	Disassembly level (%)
A	3.13	9	53.13
1	6.25	I	56.25
2	9.38	10	59.38
B	12.50	11	62.50
C	15.63	12	65.63
3	18.75	13	68.75
4	21.88	14	71.88
5	25.00	15	75.00
D	28.13	16-17 (1)	78.13
6	31.25	16-17 (2)	81.25
7	34.38	16-17 (3)	84.38
E	37.50	16-17 (4)	87.50
8	40.62	16-17 (5)	90.63
F	43.75	16-17 (6)	93.75
G	46.88	16-17 (7)	96.88
H	50.00	16-17 (8)	100.00

From the previous table it is clear that the cells are one of the most internal components of the battery. The possibility of accessing to them is bound to a disassembly level beyond a certain percentage, in this case starting from approximately 78%. The following results[106] refer to the methodology of recycling by means of reuse (REU).

Table 3.3.5) **REU scenario. Overall results.**

N° modules	Partial disassembly		Complete disassembly
	F_0 (€)	DS level (%)	F_0 (€)
0	37.37	40.62	−626.83
1	59.44	78.12	−386.67
2	235.87	81.25	−146.51
3	412.3	84.37	93.65
4	588.73	87.50	333.81
5	765.16	90.62	573.97
6	941.59	93.75	814.13
7	1118.02	96.87	1054.29
8	1294.45	100.00	1294.45

The cost-benefit function F_0 represent the cumulated benefit deriving from the two sub-objective functions, the economical and the environmental: $F_0 = y_1 + y_2$[107].

[106] Alfaro-Algaba M. et al., *Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing in Resources*, Conservation & Recycling, p. 9 <ELSEVIER> 2019
[107] Ibid. p. 3

Optimizing the function in the reuse (REU) scenario, if the battery were completely disassembled it would be necessary to be able to reuse at least three of the eight modules present in the battery to obtain a positive value for the cumulative benefits. If all eight modules were in good condition, the cumulative benefit would amount approximately to 1300 euros.

This result is extremely interesting as an amount equal to 1300 euros represents a substantial percentage of the EVB's cost. Even if this value derives from an optimal scenario, it is reasonable to think that with adequate customer fidelity policies, car manufacturers can manage the supervision of the battery packs guaranteeing a very high probability of obtaining the "optimal scenario" for each vehicle during the end-of-life steps of the products. Consequently, by investing in companies operating in the reverse supply chain, therefore having maximum control over them with the maximum efficiency of all the scraps management, it would be possible to significantly reduce production costs of EVBs. However, vertical integrations may not always be good investments like the hypothesis reported. In fact, the main reasons why vertical integrations do not occur very often concern several risks, among which: a greater capital requirement, a reduction in flexibility and the loss of specialization. The reduction in flexibility derives from the fact that, if an integrated technology becomes obsolete, the risk of incurring in high costs is considerable, not having the possibility to change supplier rapidly and simply.

Furthermore, the possibility of integration must be carefully evaluated considering the economies of scale. Indeed, integrations tend to be more profitable for companies that have larger market shares and that can better manage the production volumes of the various divisions. On the contrary, for a company that has a relatively small market share, backward vertical integration could prove to be inefficient if the production volumes of the primary components, in order to remain economical[108], must be highly above the sales possibilities.

To complete the analysis, the results[109] of the calculation of the cost-benefit function are reported also for the two other methodologies previously mentioned: REC, REM. Even if the results are not satisfactory as in the case of reuse, over the next few years the recycling activity and the material management processes can strongly improve, giving reason to believe that these results are slightly underestimated.

[108] Buzzell Robert D., *Is Vertical Integration Profitable?* <Harvard Business Review>

[109] Alfaro-Algaba M. et al., *Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing in Resources*, Conservation & Recycling, p. 10 <ELSEVIER> 2019

Table 3.3.6)

REC scenario. Overall results.

N° modules	Partial disassembly		Complete disassembly
	F_0 (€)	DS level (%)	F_0 (€)
0	−33.43	40.62	−764.54
1	−33.43	40.62	−633.13
2	−33.43	40.62	−501.72
3	−33.43	40.62	−370.3
4	16.03	87.50	−238.89
5	83.71	90.62	−107.48
6	151.39	93.75	23.93
7	219.07	96.87	155.34
8	286.76	100.00	286.76

Table 3.3.7)

REM scenario. Overall results.

N°modules	Partial disassembly		Complete disassembly
	F_0 (€)	DS level (%)	F_0 (€)
0	−11.45	40.62	−696.94
1	−11.45	40.62	−507.67
2	63.98	81.25	−318.4
3	189.53	84.37	−129.12
4	315.07	87.50	60.15
5	440.62	90.62	249.43
6	566.16	93.75	438.7
7	691.71	96.87	627.98
8	817.25	100.00	817.25

In conclusion, the results demonstrate that for significant levels of recycling or reuse of the most valuable materials present in the EVB's cells, it is always possible to obtain economic and environmental advantages, that is, possibly, cost reduction. For example, if in the next years Tesla will reuse only the 10% of the EVBs sold with their vehicles in 2020 (equal to 49.900[110]), in the optimistic scenario the cumulated benefit would amount to approximately $64.870.000,00.

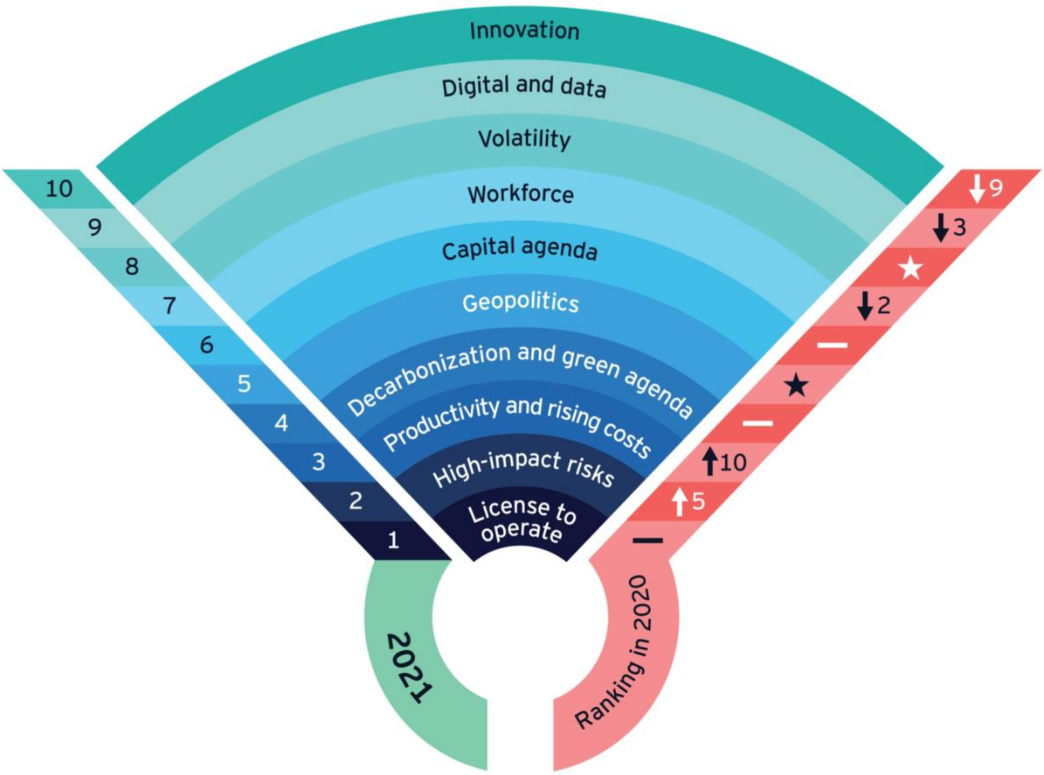
[110] 10% of 499.000 units sold in 2020.

3.4 Industry summary

From the previous paragraph it is clear that the expansion possibilities for a company operating in the electric vehicle market are different. The substantial question concerns the assessment of the investment's upside potential. As previously reported, for an automotive company oriented to develop a substantial part of its business on electric mobility, the feasible investments made by moving along the supply chain can be focused on two different areas: the procurement section and the recycling activity.

From a first rapid analysis, the hypothesis of being able to make more profitable operations by investing in the reverse production chain, i.e., companies that deal with waste management and recovery of rare metals, appears more likely.

This mainly depends on the fact that there are several companies, both in Europe and in America, operating in this field. However, this sector is still in a development phase, in fact, these companies are not particularly consolidated and therefore could be "undervalued "during assessments for M&A transactions. On the contrary, the supplier market is populated by large and well-structured companies. The opportunities to find small or medium-sized companies that can represent interesting subjects for investment operations are very low; moreover, the organization of companies involved in the mining industry is very complex. The following graph[111] shows the main risks and opportunities for the mining activity.



[111] Mitchell Paul, *Top 10 business risks and opportunities for mining and metals in 2021*, <EY Official Site> 2020

The main risk in the mining sector concerns the difficulties to obtain the licenses to operate into a specific territory. The main criticalities concern also the regulation of the states in which the operations of search and extraction of rare minerals are carried out. Nations particularly rich in natural resources can move towards an ever more stringent nationalization of the mines and natural reserves of minerals; in fact, even if large companies operating in the sector offer jobs to local population, the resources gathered from poor states appear as an impoverishment. A clear example could be the Democratic Republic of the Congo, the national territory is extremely rich in rare minerals like cobalt and lithium, two of the main components used to make EVBs. For this specific country[112], the criticalities are also linked to the exploitation of work that takes place in precarious conditions and that is highly underpaid[113]. From a geopolitical point of view, even the presence of indigenous communities can give rise to disputes relating to the rights of the inhabitants of uncontaminated places.

In addition to these problems, the highly invasive and polluting nature of mining must also be considered. The economic resources necessary to make this type of activity less aggressive and less polluting as possible require high costs. In addition to what has been reported, the global competition on the mining market must obviously be considered. For instance, one of the main threats to new entrances in the sector could be the availability of raw materials in the national territory of China, which can therefore be better extracted and managed inside the country, giving Chinese companies relevant advantages. Moreover, to implement operations in underdeveloped countries, such as the example of Congo, other difficulties could be linked to the very high rate of corruption present in the government systems.

Considering all these important threats, the best investment opportunities, in order to avoid excessive risks linked to unmanageable factors, must be sought mainly in the European and American markets.

Now most of the companies with economically attractive profiles reside in the American continent.

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[112] Conca James, *Blood Batteries - Cobalt And The Congo* <Forbes> 2018

[113] 9$/day according to Conca, Forbes 2018.

3.5 Main Companies

Previously the importance of electronic components for electric cars, specifically batteries, was underlined. The EVBs contribute substantially to the overall cost which is one of the main problems that prevents sales from reaching levels that guarantee a widespread diffusion of electric cars. One of the activities that can contribute most to reducing the cost of batteries is recycling. Companies that operate in the reverse supply chain will first be analyzed; in fact, the recycling sector, being still under development, can reveal investment opportunities with excellent IRRs. Currently, one of the most interesting firm in the reverse supply chain is American Manganese. The focus of the company is the recycling activity of EVBs with innovative techniques in order to recover the maximum quantity of rare materials. In 2019 the company patented a process[114] that by means of some chemical reactions with very low pollution, no toxic waste and low energy requirements, allows to recover high quantities[115] of metals such as lithium, cobalt, nickel and others[116]. The share price of American Manganese Inc. amount to 1,33 CAD on August 30 2021[117]. The company is listed in the Toronto stock exchange: TSX Venture Exchange.

Name	American Manganese Inc.
Ticker	AMY.V
Exchange	TSX
Share price	1,33 CAD
EPS(TTM)	-0,009 CAD
Market Cap.	286.075 M

These solutions to seek circularity in the supply chain can represent important opportunities for electric cars manufacturer's expansion which, by reducing emissions and pollution deriving from waste, could also significantly reduce the production costs of EVBs.

Another interesting company which operates in the circular recycling activity is Ly-cycle corp. The company was founded in 2016, the vision of the firm is not very different from American Manganese's, that is: both companies are oriented to create factories to find solutions for end-of-life EVBs. The company is listed at New York Stock Exchange, the share price is $8,76 on 31 August 2021[118].

[114] US Patent No.10,246,343 / Korean Patent No. 10-2246670
[115] Up to 100% of Li-Ion Battery metals.
[116] American Manganese Official WebSite: https://americanmanganeseinc.com
[117] Source: Yahoo Finance.
[118] Source: Yahoo Finance.

The vision is to build a circular use of the most valuable electronic components. The possibility of benefiting from circular economies within the supply chain can bring excellent economic results in the long term.
The next goal is oriented to analyze which could be the best investment choice among those presented.
The study is oriented to build a model that forms the basis for the integration between the two companies and that is capable to explain the risks and the upside potential of a hypothetical deal.

Chapter 4: Risks and opportunities

Introduction

The following chapter is aimed at evaluating possible investment opportunities in companies located upstream in the supply chain.
The analysis will be proposed according to different perspectives: market and corporate.
The market analysis is aimed at assessing whether there are any undervalued securities that could therefore represent candidates for "value investments", that is: investments with a medium-long term horizon with the purpose to increase the overall capital invested due to a rise in the share price[123] on the long run.
The typical analysis to assess if a company, and therefore a stock, is a good candidate for this type of investment is based on the DCF model. The objective is to evaluate, by means of realistic assumptions, the intrinsic value of the company, discounting it by a certain amount[124] defined as a "Margin of Safety" in order to understand if the stock is undervalued.
In general, any investments in the electric car industry must be evaluated with a medium-long term horizon as the market is still growing. This phase of development and uncertainty also affects the level of risk of any investments in companies with small capitalization and that are not well structured.
As example, this valuation methodology is applied to Umicore, a European company already consolidated. This company is chosen for its business model focused on the research for technical solutions that through recycling processes can make the production of EVs' components as zero greenhouse gas emissions.
Differently, the "corporate view" analysis aims to demonstrate how a good integration of efficient production processes for the recycling of EVs' components can strongly influence the operating profits.
The proposed analysis involves the construction of a model that integrates the results reported so far regarding the possible costs reduction of components such as EVBs[125].
These assumptions are applied to the historical data of Tesla Inc., then projections are developed up to 2026 forecasting all data as realistically as possible.
The purpose of the analysis is to confirm the positive trend that the electric car market is experiencing and that, by means of adequate valuations, profitable investments can be made both as simple investment in equities and with a broader corporate vision.
However, the analyses reported are composed only by hypotheses and methodologies that can be used to evaluate opportunities. Complete M&A transactions are not structured since each company has specific

[123] In addition, dividends may also be paid overtime contributing to the profit.
[124] Typically, a percentage between 20% and 50% is discounted, depending on the "safety" required. Investments valued with a margin of safety above 30% typically avoid significant losses thanks to a high margin of error allowed during the valuations.
[125] In the most optimistic case, a reduction of up to 10% of the EV's cost was reported.

characteristics, so generic models excessively simplified could be inadequate to evaluate transactions in depth.

4.1 EV market as long-term investment

The current development of electric mobility makes it possible to seek investment opportunities in companies that are not yet definitively consolidated, which can therefore prove to be excellent candidates in terms of value investing.

One of the fundamental characteristics that defines companies operating in the EVs industry concerns the strategy adopted for their business development.

Considering the growth that the electric car market has undergone in the last decade and the estimated future development, which should increase considerably encouraged by the widespread policies, there are probabilities to find undervalued stocks. Equities with these characteristics can be excellent investment choices in the medium-long term. According to this perspective, both companies that deal with the production and sale of vehicles but also companies specialized in the production and disposal of EVs' components can be considered. Indeed, these two markets are significantly correlated. The following table shows the correlations between some of the companies' stock value previously described, plus two of the main electric car manufacturers, namely: Tesla and Toyota.

Correlation	Tesla	Savannah	Piedmont Lithium	Toyota
Tesla	1	0,802	0,568	0,487
Savannah	0,802	1	0,694	0,355
Piedmont Lithium	0,568	0,694	1	0,671
Toyota	0,487	0,355	0,671	1

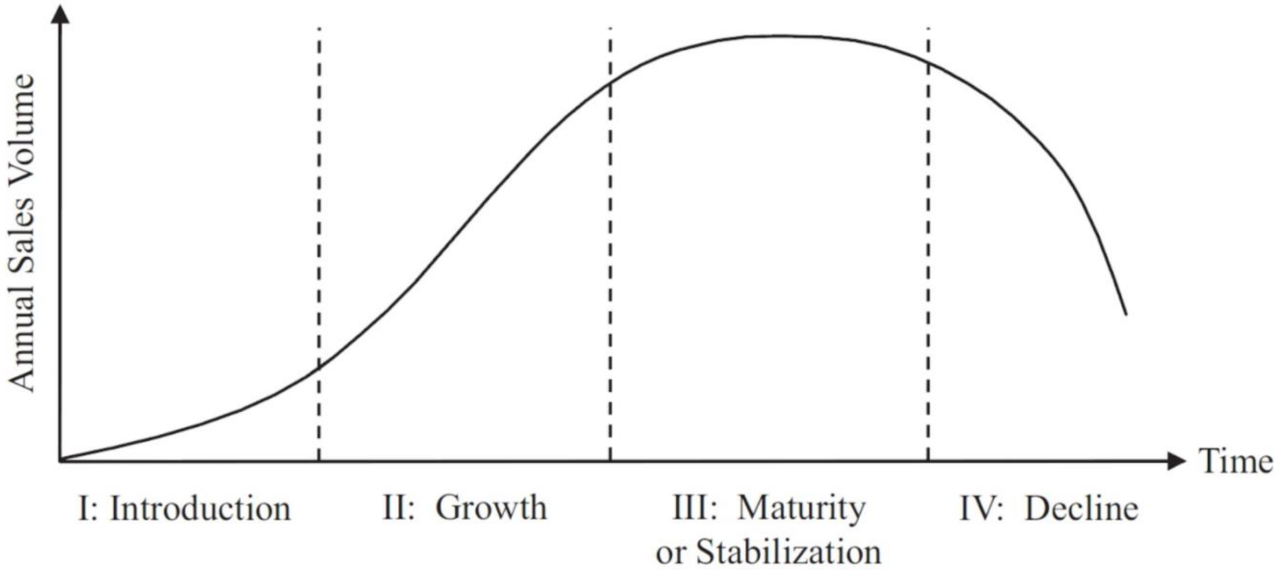
Considering the nature of this industry and the correlation results reported, it is reasonable to think that the sectors directly connected to the EVs manufacturing are also destined to grow significantly in the coming years. Indeed, the projections regarding the EVBs' market forecast the growth at a CAGR of 25.3%, going from 27.3 billion in 2021 to 67.2 billion in 2025[126].

All the data and information suggest that interesting investment opportunities with a medium-long term horizon should be possible.

Many states are implementing policies oriented to encourage the adoption of electric cars and also limiting the chances of survival for the most polluting types of vehicles.

[126] MarketsandMarkets official WebSite, *EV Battery Market by Battery Capacity (<50, 50-110, 111-200, 201-300 and >300), Battery Form (Wire, Laser), Propulsion (BEV, PHEV, PHEV, FCEV), Battery Type, Material Type, Li-ion Battery Component, Method, Vehicle Type & Region - Global Forecast to 2025* <MarketsAndMarkets> 2021

The main objective is to reach an adequate level of EVs' use by 2030, however, is preferable to take into account a longer time horizon since the next few years will involve a phase of growth, while the subsequent phase will have the opportunity to produce stable profits thanks to a mature sector.
Table 4.1.1)



Observing a typical graph of products' [127] lifecycle, we can assume that up to 2030 the phases of introduction and growth of the product will be faced. Otherwise in the following years we will go across the stage of maturity which in the case of the automotive market could last for a long time[128].
Starting from this assumption it is necessary to understand the growth potential of companies active in this industry in order to identify which of them have the best characteristics to ensure growth in line with the expected development of the sector.
The essential characteristics concern the ability of these companies to generate adequate cash flows over the next few years. However, this kind of sector imply the presence of risks that are difficult to quantify.
For example, American Manganese (one of the previously mentioned companies) clearly states the risks associated with the company's operations in a note into the following financial statement.
The most relevant parts are highlighted.

[127] Gleason Derek, *Product Lifecycle Marketing: What Matters Most at Every Stage* <Business2Community> 2019
[128] The Car equipped with an ICE as a source of power is a product that has lasted for more than a century.

AMERICAN MANGANESE INC.

Notes to the Consolidated Financial Statements
For years ended July 31, 2020 and 2019
(Expressed in Canadian dollars, unless specifically indicated otherwise)

1. Nature and Continuance of Operations

American Manganese Inc. (the "Company") was incorporated under the laws of British Columbia on July 8, 1987, and is a publicly-traded company with its shares listed on the TSX Venture Exchange trading under the symbol "AMY". The Company is principally engaged in the acquisition, exploration and development of interests in mineral resource projects in British Columbia, Canada and Arizona, USA, with a focus on patenting intellectual property for recycling lithium-ion electric vehicle batteries. To date, the Company has not generated any revenues and is considered to be in the exploration stage.

The address of the Company's corporate office and principal place of business is Unit 2 – 17942 55th Avenue, Surrey, British Columbia, Canada, V3S 6C8.

These consolidated financial statements comprise the financial statements of American Manganese Inc. and its wholly-owned subsidiary, Rocher Manganese Inc. ("RMI"), incorporated in the state of Arizona, USA.

The business of exploring and developing mineral resource properties involves a high degree of risk, and there can be no assurance that planned exploration and development programs will result in profitable mining operations. The recoverability of amounts shown for capitalized exploration and development costs is dependent on the ability of the Company to obtain necessary financing to complete the development and future profitable production or, alternatively, upon disposition of such properties at a profit. Changes in future conditions could require material write-downs of the carrying values of exploration and evaluation interests.

Although the Company has taken steps to verify title to mineral properties in which it has an interest, in accordance with industry standards for the current stage of exploration of such properties, these procedures do not guarantee the Company's title. Property title may be subject to unregistered prior agreements or transfers and may be affected by undetected defects.

Management estimates that the Company will have adequate funds to meet its corporate, administrative and other obligations during the upcoming July 31, 2021 year-end. The Company has financed its exploration and research and development activities and operations through equity issuances and expects to continue to do so to the extent such instruments are issuable under terms acceptable to the Company and until such time as its operations provide positive cash flows. However, while, the Company has been successful in raising financing in the past, there is no guarantee that it will be able to do so in the future.

If future financing is unavailable, the Company may not be able to meet its ongoing obligations, in which case the realizable value of its assets may decline materially from current estimates and the Company will be required to re-evaluate its plans for expenditures and allocate its resources in a matter that both the Board of Directors and senior management deem to be in Company's best interest. Such a plan may result in significant deviations from the Company's original plans for operations and main business purpose. The consolidated financial statements have been prepared on a going concern basis which assumes that the Company will continue to realize its assets and discharge its liabilities in the normal course of operations.

Source: American Manganese Inc. Official WebSite, Consolidated Financial Statement for years ended July 31, 2020 and 2019, p. 5

The note clearly states the risks associated with the development of companies operating in this innovative industry. Profitability strongly depends on some unmanageable and unpredictable factors. The development of the company took place through equity issues that guaranteed the continuation of business, however in the event that future financing possibilities will no longer available, the company would unlikely be able to meet its financial obligations.

Certainly, American Manganese Inc. has some very interesting developmental features.

The new patented process for the recycling of EVBs named RecycLiCo[129] is a valuable intellectual property. However, this business activity may prove unprofitable for some years. Indeed, currently the number of electric cars already sold is not very high. The batteries in use have discrete duration which implies that in order to reach profitable working volumes connected to the exhausted EVBs it is necessary to wait for a greater diffusion of electric vehicles.

[129] Patented process in 2019.

4.2 Main risks and opportunities

The EVs' market characteristics and growth prospects make this industry very attractive to the capital markets. The technology and the need for innovative alternatives have made the capital market of the electric mobility one of the most performing in recent years.
The following table reports the data for the total returns to shareholders in 2019-20 (weighted average by market cap as of June 1, 2019)[130].

Capital market performance by industry cluster	
New mobility	167%
Semiconductor	63%
Big tech	51%
Traditional auto	18%
Insurance	11%
Telco	80%
Energy oil & gas	-16%

Source: S&P Capital IQ; McKinsey analysis

In this historical moment the market is dragged by some drivers. As already mentioned, the macroeconomic environment with policies and national regulations are pushing states towards the adoption of EVs. Markets dynamics are driven by regulations increasingly oriented to incentivize consumers towards the purchase of electric cars. The investments in infrastructures are implemented by paying maximum attention to environmental problems which for some years now represent a real threat that has to be managed and contained by means of technological development[131]. The new technologies contribute to increase the possibility that in the short term the TCO of electric cars may be reduced below the ICE's one.

[130] Gao Paul et al., *The irresistible momentum behind clean, electric, connected mobility: Four key trends*, McKinsey Quarterly <McKinsey&Company Official WebSite> 2021
[131] Gersdorf Thomas et al., *Electric mobility after crisis: Why an auto slowdown won't hurt EV demand,* <McKinsey&Company Official WebSite> 2020

All the qualitative indicators seem to be in favor of companies operating in the electric mobility industry. However, the sector is not free from risks both specific (directly connected to the individual business) and exogenous (related to the market as a whole)[132].
An exact risk assessment is almost impossible due to the highly innovative nature of the market. The main exogenous risk factors concern negative events related to the industry as a whole, while the specific risks for a company are connected to factors and information not disclosed.
For instance, environmental scandals linked to mining activities focused on the development of electric mobility could raise doubts about the real environmental benefits of the technological shift. Government incentives play an essential role for the market development, the presence or absence of them such as tax breaks can strongly affect the development of the EVs' market share in any country. The absence of investments in infrastructures that facilitate the development of electric mobility is a serious risk.
A further reduction[133] in the price of oil could keep convenient technologies and businesses that use fossil fuels; after that there is probably the most significant risk, that is, the long-term perspective required for the investments in this sector to be profitable. Indeed, the temporal uncertainty about the time needed to ensure that the electric car market share would be large enough to guarantee convenient sales volumes both for manufacturers and constituent of the supply chain is a not negligible factor during assessments for an investment.

[132] Duchesne G. et al., *(R)evolution in mobility: The impact of electricity*, BNP PARIBAS Wealth Management Official WebSite, 2018
[133] During the COVID-19 pandemic crisis the price of crude oil fell dramatically.

4.3 Value inventing

The possibility that some companies among those operating in the various levels of the EVs' supply chain will experience significant increases in cash flows and therefore in profits is high. This statement is supported by the strong correlation between the electric car market and other supply chain activities. In fact, for a correct development of the EVs market it is essential that the procurement and recycling activities, specifically regarding the EVBs' components, are developed and efficient. However, at the moment, most of the companies operating in the backward supply chain report negative cash flows for the last few years, this is partly due to the global crisis caused by the covid-19 pandemic and also to the extremely uncertain nature of the activities which depend on some exogenous factors. The share prices of these companies, including those listed in the previous chapter are very low.

Some of them have excellent corporate vision and operating models that could prove to be extremely profitable if the company were able to start its operations properly. However, economic valuations are primarily based on the ability to produce revenues on medium-term horizon and these kinds of assessments are typically based on historical data, assuming that the company have them for the previous years. In other cases, such as for start-ups, in which the business model is innovative and historical data is missing, more qualitative than quantitative analyses are made.

The companies reported in the previous chapter can be compared almost to start-ups, specifically the business divisions that deal with the EVBs recycling technology. Indeed, the electric car market is in its infancy, the EVBs recycling business is still partly in the testing and development phase. From a market perspective, these companies' stocks are not particularly attractive. Firms like American Manganese report losses and necessity of financing to continue the business operations. Most of these companies do not have stable and constant profits and their stocks have a high volatility. The table 4.3.1 shows the daily Value-at-Risk[134] at 5% for two of the previously reported companies.

[134] VaR is one of the main measures to quantify the market risk. Specifically, it measures the maximum potential losses that can be reported in a given time spot and with a certain level of confidence, typically 95% and 99%. It is a very useful measure for assessing the risk of a portfolio or even a single security as it allows to quantify, based on historical data, the maximum achievable monetary loss.

Table 4.3.1)

Parametric Approach VaR				
	American Manganese		Piedmont Lithium	
	Returns	**Price Change**	**Returns**	**Price Change**
Mean	0,663%	0,0041	0,308%	0,0867
Standard Deviation	0,0880	0,0935	0,0690	3,2934
Skewness	2,32	2,171	-0,167	-0,496
Kurtosis	12,18	11,600	5,503	3,697
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VaR	**13,81%**	**0,15**	**11,04%**	**5,33**

The numbers for the Value at Risk reported are indicative of the high uncertainty of the two companies. Typically, for consolidated and stable firms, the daily 5%[135] VaR is around 3% of the share price; specifically, the average daily VaR at 5% for Bank of America, Wells Fargo and Procter&Gamble is 2,70%, significantly lower than the values above

A reasonable level of return must clearly be associated with the risk profile of these companies. However, accurate and realistic assessments for companies operating in this sector without having any type of internal information are almost impossible to make.

From a value investing perspective, the valuation methodology should be based mainly on the assessment of future cash flows starting from a series of historical data. By means of this methodology, the intrinsic value of the company is typically obtained. If the company is considered undervalued compared to his market value, discounting an adequate margin of safety[136], the stock can represent a good "value investment".

This method is applied to Umicore in the following model (Table 4.3.2 and 4.3.3).

Umicore is a European company active in the development of sustainable processes for the production and recycling of EVs' components.

[135] 95%(100%-5%) is the level of confidence. In this case the statement could be "We are 95% percent certain that we well not lose more than the 3% value of the securities in one day". For instance, investing $100.000 certainly the maximum amount that can be lost in one day is $3000, or the probability that the losses will be greater than $3000 is 5%.

[136] The margin of safety can be defined as the difference between the market price and the intrinsic value of a security.

Table 4.3.2)

in thousand	Historical FYE12/31,				Projected FYE 12/31,				
	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Revenue	11.947.264 €	13.716.736 €	17.485.081 €	20.710.116 €	24.902.381 €	29.943.270 €	36.004.565 €	43.292.825 €	52.056.416 €
Growth Rate %	-	14,81%	27,47%	18,44%	20,24%	20,24%	20,24%	20,24%	20,24%
	--------	--------	--------	--------	--------	--------	--------	--------	--------
EBITDA (also called operating cash flow)	599.000 €	720.000 €	753.000 €	804.000 €	1.148.713 €	1.484.750 €	1.785.301 €	2.146.693 €	2.581.239 €
Book depreciation and amortization	190.494 €	206.577 €	244.038 €	267.941 €	360.458 €	422.422 €	499.355 €	599.488 €	732.678 €
Margin (%)	1,59%	1,51%	1,40%	1,29%	1,45%	1,41%	1,39%	1,38%	1,41%
EBIT (also called operating income)	408.506 €	513.423 €	508.962 €	536.059 €	788.254 €	1.062.327 €	1.285.946 €	1.547.204 €	1.848.561 €
Tax Rate	25,70%	24,40%	24,70%	24,20%	24,75%	24,75%	24,75%	24,75%	24,75%
Taxes	153.943,00 €	175.680,00 €	185.991,00 €	194.568,00 €	284.306 €	367.476 €	441.862 €	531.306 €	638.857 €
	--------	--------	--------	--------	--------	--------	--------	--------	--------
Book depreciation and amortization	190.494 €	206.577 €	244.038 €	267.941 €	360.458 €	422.422 €	499.355 €	599.488 €	732.678 €
Capital Expenditure	-	- 478.747,00 €	- 553.849,00 €	- 403.535,00 €	- 423.711,75 €	- 466.082,93 €	- 512.691,22 €	- 563.960,34 €	- 620.356,37 €
Net Working Capital			549.000 €	603.000 €	645.210 €	699.524 €	753.450 €	814.205 €	878.415 €
Delta Net Working Capital				54.000 €	42.210 €	54.314 €	53.926 €	60.755 €	64.210 €
Free Cash Flow			-		**398.485 €**	**596.877 €**	**776.822 €**	**990.671 €**	**1.257.816 €**
WACC	7%								
Discount period					1	2	3	4	5
Discount factor					0,93	0,87	0,82	0,76	0,71
Present value of Free Cash Flow					372.415 €	521.336 €	634.118 €	755.778 €	896.805 €
Cumulative Present value of Free Cash Flow	3.180.453 €								

Table 4.3.3)

Present value of Free Cash Flow	
Cumulative Present value of Free Cash Flow	3.180.453 €
Terminal Value	
Terminal year EBITDA (2025E)	2.581.239 €
Exit multiple	7,09
Terminal Value	18.294.826 €
Discount factor	0,67
Present value of Terminal Value	12.190.615 €
Perpetual Growth Rate	2%
Enterprise Value	**15.371.068 €**
25% Margin of Safety	11.528.301 €
n° Shares Outstanding	240.580
Fair "Value Investment" Price	**47,92 €**

Based on the projections made, the results state that applying a margin of safety equal to 25%, it would be reasonable to purchase Umicore's stocks at a price lower than 48 euros approximately. This analysis was developed by making reasonable assumptions on revenues' growth rate. These values could theoretically be underestimated too, considering the expected growth that the electric car market should experience in the coming years.

However, accordingly to Graham and Dodd[137], there are three main obstacles to the application of this kind of model to unconsolidated companies with relatively small market capitalization: inadequacy or incorrectness of the data, uncertainties of the future and the irrational behavior of the market.

In this particular case the first criticality is significant.

The lack of in-depth information, the precarious financial conditions and the losses reported for several years make the application of models like this one hard to apply to companies like American Manganese.

Under these conditions, the evaluations could be carried out with a qualitative rather than quantitative profile. Similar approaches are applied to startups evaluations[138].

The main characteristics to be observed using this methodology are: the nature of the business, the relative position of the individual company, the operating characteristics, the knowledge of the management and a generic outlook of the industry[139].

For the previously mentioned company (American Manganese Inc.), the table 4.3.2 report a section of the Management Discussion and Analysis of 2020.

[137] Graham B., Dodd L. D., *Security analysis*, Sixth Edition p.68 <McGrawHill> 2009, First edition 1934.

[138] For startups the profitability and growth projections are typically conducted with qualitative assessments due to the absence of historical data and similar business models to use as a comparable.

[139] Graham B., Dodd L. D., *Security analysis*, Sixth Edition p.82 <McGrawHill> 2009, First edition 1934.

Table 4.3.4)

Nature of business

The business of the Company is mineral exploration and development with a focus on patenting intellectual property for recycling lithium-ion electric vehicle batteries. The company's mineral and technological projects are described below.

Intellectual property rights

In June 2019, the Company is granted Continuation in Part (CIP) U.S. patent No. 10,308,523B1 for Lithium-ion Battery Cathode Material recycling technology.

In May 2019, the Company has selected China, Japan, South Korea, Europe, Australia, India, and Canada to file National Phase Patent Applications for the Company's lithium-ion battery cathode material recycling technology.

In April 2019, the Company is granted U.S. Patent No. 10,246,343 for Lithium-ion Battery Cathode Material recycling technology.

Patent Co-operative Treaty Patent Application filed on November 9, 2017. With the filing of the PCT Application, the Company's proprietary technology becomes patent pending in 152 participating independent states and countries.

Non-Provisional Patent Application for recycling lithium-ion battery cathode material filed with the United States Patent Office on November 7, 2017.

Advanced Hydrometallurgical Process where from manganous sulphate-dithionate liquor electrolytic manganese can be recovered from a low-grade resource (US Patent No. 8460681, Chinese Patent No. 201180050306.7, Republic of South Africa Patent No. 2013/01364, Canada Patent No. 2,808,627).

Source: SEC Official WebSite.

Despite the company is active in the mining industry, the main focus is aimed to the development of intellectual properties for the EVBs recycling processes. In June 2019 the company has already patented an extremely interesting process that allows the recovery of very high percentages of rare metals from exhausted batteries limiting the levels of pollution and energy consumption.

The management of the company seems to be decidedly solid. Both the CEO (Larry W. Reaugh) and the CFO (Shaheem Ali) are professionals with many years of experience in the mining industry[140]. The Chief Technical Officer, Zarko Meseldzija, has abundant previous experience too and he is the owner of a consulting firm that is focused on the lithium batteries life cycle and supply chain management.

Clearly this information concerns the references of these people and are publicly available. In addition, for what concerns the market outlook, the future prospect for the industry is definitely good.

All the variables seem to be in favor of the development of the electric mobility, starting from most of the governments' incentives to the development of technologies able to make electric cars accessible and sustainable.

[140] American Manganese Inc. Official WebSite.

As a result, will be proposed a model that assume the purchase and the integration of a company such as American Manganese in the operating production of Tesla Inc.
All the data used in the model will be aimed at analyzing the benefits obtainable from integrations of this type by making assumptions as realistic as possible.

4.4 M&A: Vertical integration opportunities

The following chapter assumes the acquisition of one of the previously mentioned companies by Tesla Inc. The study is not carried out to build an overall assessment of the operation but rather hypotheses on what its results on Tesla's operations may be.

The target company will be American Manganese for two reasons: the company is relatively small and its market capitalization is low compared to Tesla, indeed the American Manganese's market cap amounts to 260.264 million of Canadian dollars[141] while Tesla's amount to 751.551 USD Billions[142].

The company is reporting a negative Earning per Share and its operations remain bounded to the financing possibilities.

Despite the technical knowledge and the favorable industry, the company is financially unstable.

On the contrary, Tesla is a well-established company. It is one of the largest electric vehicle manufacturers in the world. Despite the C.E.O. Elon Musk took questionable decisions, such as investing 1.5 billion in cryptocurrencies[143] of dubious economic value, the company in the last two years has reported positive cash flows despite the covid-19 global economic crisis. The company has also a considerable amount of cash and cash-and-cash equivalents, this could avoid an excessive recourse to debt.

Considering the limited financial information, the model reported below is aimed at demonstrating how a reduction in the cost of automotive components can strongly influence the income from operations.

The cost reductions can be attributable both to reduced prices for some raw materials and to the optimization of technical production processes, specifically to produce EVBs.

The greatest economic benefits could derive both from the use of patented processes owned by American Manganese and from some properties of the company such as the Artillery Peak Project, Arizona USA.

However, the assets of the company can be exploited according to their convenience. For instance, the project in Arizona USA does not have as its main objective the extraction of lithium, so if it was considered "obsolete" for Tesla, it could be sold.

Similarly, other types of assets such as factories or machinery considered unnecessary could be subsequently liquidated, keeping only the systems that contribute to increase the profitability.

The following model (Table 4.4.1) reports historical data for Tesla for the time frame 2018-2020, the subsequent years are calculated as historical data projections.

The model is based on Tesla's consolidated statement of operations.

The growth rate of revenues is calculated as an average of the past three years minus a certain percentage, in this case 4%, the result is equal to 18.20%. This value guarantees a fair growth for the projections, consistent

[141] 206.019 USD Millions
[142] Yahoo Finance, September 16, 2021.
[143] Bitcoin.

with what has been previously described about the expected growth of the EVs' market and with the presumed economic recovery following the covid-19 pandemic. In fact, a more conservative choice would be to assume a growth rate for the revenues slightly lower than the average of the previous years making the model more reliable.

The main assumptions concern a reduction in the automotive costs of sales (4%) plus a small reduction in the research and development expenses (1%).

The first one is chosen in accordance with the research reported in the previous chapters regarding the possibility of reducing the costs of the EVBs up to 10%[144] of the total cost of a single car, while the second is imposed considering that the acquisition of some patented processes can slightly reduce the expenditure for the research and development in subsequent years.

[144] A reduction of 10% is not actually calculated since it is a decidedly optimistic forecast and therefore could make the results less reliable.